

ELECTRONIC FUNDAMENTALS

Service Practices 31:

AM AND FM SIGNAL GENERATORS

Service Practices 32:

CATHODE RAY OSCILLOSCOPE I



RCA INSTITUTES, INC.

A SERVICE OF RADIO CORPORATION OF AMERICA

New York,

N. Y.

ELECTRONIC FUNDAMENTALS

SERVICE PRACTICES 31

AM AND FM SIGNAL GENERATORS

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Service Practices 31

INTRODUCTION

Of the many test instruments, tools, and accessories used by the serviceman, the signal generator is one of the most important because of its relative versatility and low cost. It is a basic instrument for any professional shop.

Besides being used for alignment of oscillators and r-f and i-f amplifiers in radio receivers, the signal generator can be used in a number of other ways to make troubleshooting faster and more profitable. For example, it can be used to locate a defective stage or section in a receiver. A signal from the signal generator can be fed into the antenna terminals of the receiver; and a vacuum-tube voltmeter, an oscilloscope, or some other indicating device can be used to trace the progress of the signal, step by step, from the r-f stage through to the audio-output stage. The signal can also be injected at other points, thereby providing a means of detecting a faulty stage or section. Also, the generator can be used to provide a substitute signal in checking for a weak or dead oscillator stage, or for locating trouble in audio amplifiers. The audio generator is necessary for making frequency-response checks. The procedures and servicing techniques employed in using signal generators for these applications are described elsewhere in this course. This lesson discusses the operation of types of signal generators and points out the features that make them such valuable servicing instruments. Several typical commercial instruments are described. The terms generator and oscillator are used interchangeably in referring to these instruments and have the same meaning. The four basic types of signal generators used by servicemen are:

1. R-F signal generators.
2. Sweep (FM) signal generators.

3. A-F signal generators.

4. Square-wave generators.

The four basic types of service-type instruments discussed here have a great deal in common.

31-1. THE R-F SIGNAL GENERATOR

The r-f signal generator is useful in servicing both AM and FM radio receivers and television. It provides an output signal that can be tuned to any frequency from approximately 100 kc to 30 mc. The amount of r-f voltage output is adjustable, and the signal may be modulated internally or externally. Signal generators come in different models at different prices. In order to select the model that fills your needs, it is helpful to know the features of these instruments and how they are used in service work.

Frequency Coverage. The r-f signal generator should provide an output signal on fundamental frequencies from approximately 100 kc to 30 mc. The output at relatively low radio-frequencies is necessary in alignment of i-f amplifiers in AM broadcast receivers. Modern home receivers employ intermediate frequencies of 455 and 465 kc, and many auto radios use a 260-kc intermediate frequency. Earlier models, many of which are still in use, utilize 175 kc. Some communications receivers that employ a double-conversion i-f system use two i-f amplifier sections, one of which may operate at frequencies as low as 85 kc. Alignment of conventional amplifiers requires a signal generator which can deliver a signal down to at least 175 kc. Sufficient overlap in the tuning range should be allowed.

The higher range of frequencies is useful for alignment of oscillators and AM broadcast receivers. The highest frequency required for these receivers is 1,400 to 1,600

SERVES
AM - FM
100 KC - 30 MC

AM
FREQUENCIES

LOWEST
AM FREQ

HIGHEST
AM FREQ.

BASIC
INSTRUMENT

USES

SIGNAL
TRACING

SUBSTITUTE
OSCILLATOR

FREQUENCY
RESPONSE
CHECKS
(A F)

TYPES

kc. However, many home receivers have short-wave bands that handle frequencies as high as 25 or 30 mc. The oscillators in such receivers operate near the tuning frequencies, so they require a high-frequency alignment signal. FM broadcast receivers which are designed to cover the 88- to 108-mc tuning range require a still higher signal. Also they present a special problem because of frequency-stability, voltage-output, and leakage difficulties associated with high frequencies. Since most service-type signal generators are designed for applications below 30 mc, they cannot be used for servicing FM sets. However, some instruments are equipped with specially calibrated scales for frequencies up to 200 mc. In these instruments, the second or fourth harmonics of signals that can be produced by the oscillator are used. Harmonic signals are generated by all r-f generators, although the harmonic signals have a considerably reduced amplitude in comparison with the fundamental frequency.

Attenuator Systems. Different signal levels are required in different tests. The purpose of the attenuator is to permit adjusting the output-signal level to the exact value needed. For example, when injecting a signal at the antenna terminals, it is desirable to use a low-level signal to prevent overloading the receiver front-end. A low-level signal is also desirable, in aligning i-f amplifiers, in order to prevent AVC action from affecting output indications and in order to check receiver sensitivity at low levels. In other applications, a test signal of much higher voltage is required. A good r-f signal generator should have an adjustable attenuator on the front panel to permit adjustment of the output signal from a few microvolts to the maximum output voltage.

Attenuators are of two types, step-switch and continuously adjustable. A potentiometer or a multiposition switch with prefixed-attenuator positions may be used. Some generators utilize both types. The attenuator should provide smooth, even attenuation over the entire output-voltage and frequency range.

Shielding and Filtering. Undesired radiation through the generator case, from the

power line, and from connecting cables can cause serious interference with the test procedure, especially during low-level tests and at high frequencies.

Shielding of the oscillator stage inside the case and the use of a metal instrument case also help to reduce interference. The r-f tightness of the generator case becomes more important at the higher radio frequencies, where small openings offer radiation outlets for the signal.

Interference due to unwanted coupling of the oscillator signal through the power line is reduced by a low-pass filter in the primary side of the power transformer. These filters present a high-impedance path in the line to frequencies above the line frequency and serve to short-circuit r-f signals to the generator ground. An electrostatic shield inside the power transformer is also helpful.

Unless the output cable is thoroughly shielded and provided with a ground connection at the point of signal injection in the receiver, severe interference problems can result. The r-f signal generator should be equipped with a coaxial-type output cable thoroughly shielded from connector to test point.

Accuracy and Stability. The service-type r-f signal generator is not a precision instrument when compared with laboratory standards, but precision is not required in general service work. However, the tuning-dial calibration should be dependable, and have an accuracy within about two percent. Stability is more of a problem at high frequencies, where line-voltage fluctuations, changing temperatures, and oscillator loading by the test circuit can cause the generator frequency to drift or pull. Dial-calibration accuracy is usually specified by the manufacturer. Stability performance is not usually defined and may be difficult to determine unless you make performance tests. An amplifier stage, (called a buffer) between the signal generator and the output circuit is desirable to keep loading effects of the test circuit from affecting the oscillator frequency and to provide amplification of the oscillator signal. It is generally advisable to allow the generator 15 to 30

SHORT
WAVE
FREQUENCIES

FM
CONSIDERATIONS

NEED
SPECIAL
INSTRUMENT
TO 200 MC
FOR FM

NEED
FOR
CONTROL
OF OUTPUT-
SIGNAL
LEVEL

STEP-
SWITCH AND
CONTINUOUSLY
ADJUSTABLE
ATTENUATORS

RF
RADIATION
PROTECTION

TIGHT
METAL
CASE

POWER
LINE
COUPLING
PROTECTION

LOW
PASS
FILTER
ELECTRO-
STATIC
SHIELD

SHIELDED
CONNECTOR
NEEDED

DIAL
ACCURACY
2%

STABILITY
NEEDED
AT HF

AMP.
STAGE
TO PREVENT
LOADING

minutes warm-up time to achieve maximum stability before attempting receiver alignment.

Voltage Output. Because the generator is used with a variety of load resistances, the maximum output voltage is usually specified for open-circuit operation. In practice, loads in the order of 100,000 to 300,000 ohms are common, and the generator should provide a maximum output signal of between 0.01 and 0.05 volt throughout its tuning range. Because voltage output tends to decrease as the generator frequency is raised, the voltage output is usually greater on the lower ranges.

Modulation Facilities. The r-f signal generator should have a built-in audio oscillator for modulating the r-f output signal.

A modulated signal is necessary to provide an audio-voltage reading at the second detector in AM receivers and to produce an audio tone from the loudspeaker. A simple transformer-coupled audio oscillator is usually built into the generator and provides modulation at 400 cps. Modulation in the order of 30% is usually employed. The audio signal should also be available separately at the front panel to permit use of the generator in checking audio-output stages and in troubleshooting audio amplifiers.

If the signal generator is equipped with a jack for injecting external audio signals into the oscillator stage, the instrument can be modulated at different frequencies within the audio range. This feature is useful in running over-all frequency-response checks on receivers.

NEED
FOR AUDIO
MODULATION

400 cps
30%

EXTERNAL
AUDIO
OSCILLATOR

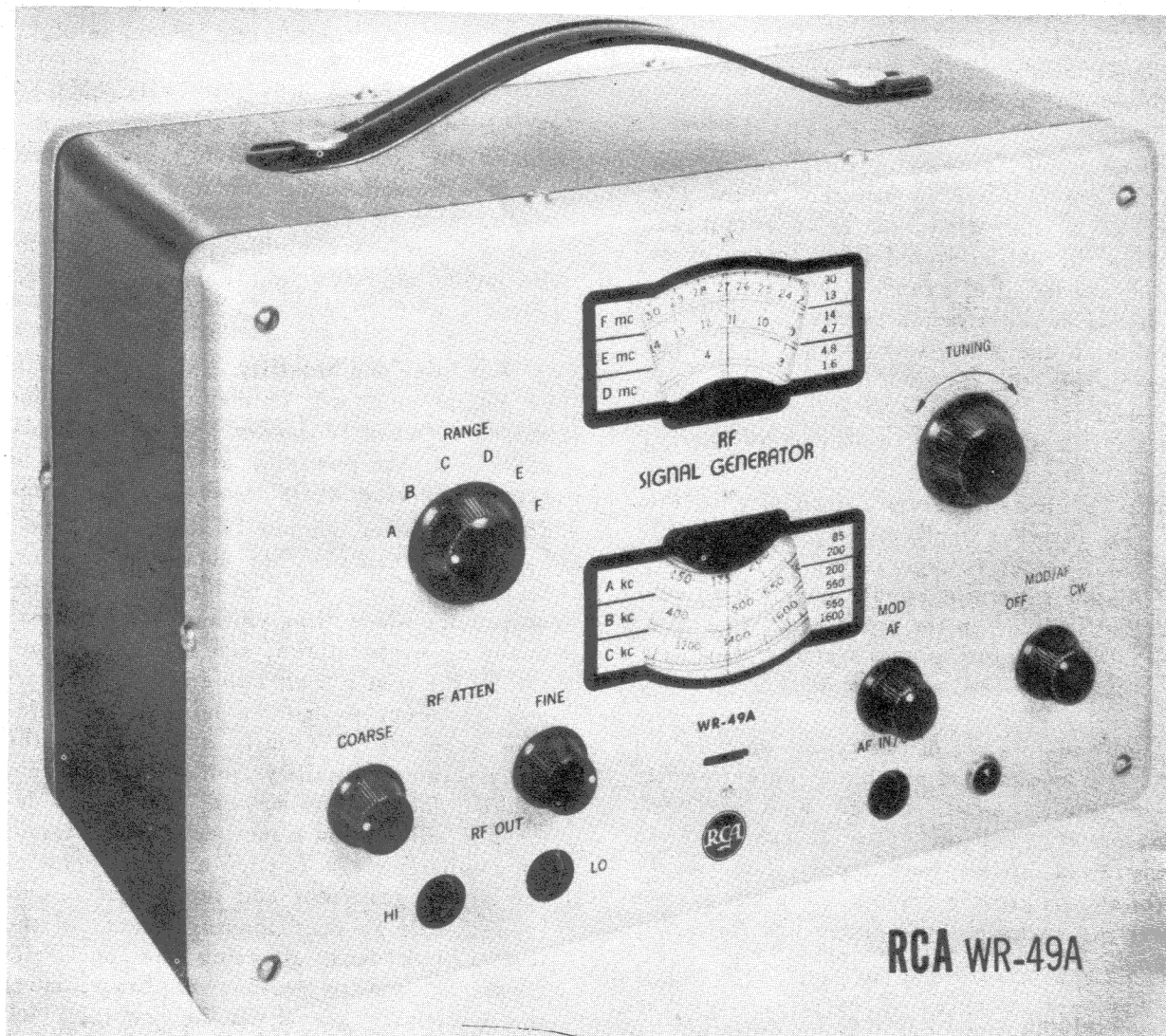


Fig. 31-1

WARM
UP
15-20 min

ATTEN
FOR
OPEN
CIRCUIT

LOADS
AND
MAX
OUTPUT

31-2. TYPICAL R-F SIGNAL GENERATORS

The RCA WR-49A R-F Signal Generator.

A representative r-f signal generator, the RCA WR-49A, is shown in Fig. 31-1. The WR-49A incorporates circuitry and features similar to those employed in other instruments. This instrument is designed for general radio and television servicing and other applications which require a continuous wave or modulated r-f signal of sine-wave form from 85 kc to 30 mc. The function of the front-panel controls is as follows:

The OFF MOD/AF CW control turns power off in the OFF position. In the MOD/AF position, modulated r-f output is available at the RF OUT connectors, one of which is labelled HI and the other LO. In the CW position, unmodulated r-f output is available at the r-f output connectors. When external modulation is supplied to the instrument, this control is set to CW.

The RANGE control is used to select the desired tuning range. Lower frequencies from 85 kc to 1,600 kc are read from three lower dial scales marked A, B and C. Higher frequencies are read from three top dial scales marked D, E and F.

The TUNING control is used in conjunction with RANGE control to adjust r-f output to the exact desired frequency.

The RF OUT section has two connections for the output cable. These connections are labelled HI and LO. Maximum r-f output voltage is available at the HI connector and an r-f signal of lower level is available at the LO connector. The amount of output from either connector may be set by adjustment of the RF ATTEN controls.

The RF ATTEN controls COARSE and FINE, are used to vary the amount of r-f output signal available at the RF OUT HI and LO connectors. The COARSE control provides the greatest range of attenuation; the FINE control provides precise adjustment.

The AF IN/OUT connector has two functions. When the OFF MOD/AF CW control is set to MOD/AF, a 400-cps audio

signal from the internal audio oscillator is available at the AF IN/OUT connector. When the switch is turned to CW and the MOD AF control is turned fully clockwise, an external modulating signal, up to approximately 15 kc, may be injected to modulate the r-f output available at the RF OUT connectors. When external modulation is used, it is important that the MOD AF control be turned clockwise to prevent short-circuiting the modulating signal to ground. This control may also be used as an attenuator to regulate the amount of injected signal.

The MOD AF control has two functions. It varies the degree of internal modulation applied to the r-f oscillator when the OFF MOD/AF CW control is set to MOD/AF. It also varies the amount of audio output signal available at the AF IN/OUT connector. When an external modulating signal is applied to the r-f oscillator through the AF IN/OUT terminal, the OFF MOD/AF CW control should be set to CW and the MOD AF control should be turned fully clockwise.

A block diagram of the WR-49A is shown in Fig. 31-2 and a schematic diagram is given in Fig. 31-3. The generator employs two electron tubes and a selenium-type power rectifier in circuits of conventional design. The r-f oscillator employs one triode section of a 12AU7 in a Hartley oscillator circuit, which is commonly used in generators of this type. The oscillator output is coupled to the second triode section, which serves as a cathode follower. A 6C4 triode is used as a transformer-coupled audio oscillator. Separate tuning circuits are used for each of the six r-f ranges, and the appropriate circuit is connected by means of the RANGE switch. The circuits are designed to overlap in coverage and each is tuned with the same tuning capacitor, C_8 . Capacitors C_1 through C_6 and inductances L_1 through L_6 are provided with internal screwdriver adjustments for alignment purposes.

The r-f output circuit contains two potentiometers for coarse and fine adjustments. Note that the LO output is taken off a voltage divider consisting of R_5 and R_6 that attenuates the signal voltage available at the LO terminal. C_{14} and C_{15} are d-c blocking capacitors, which couple the r-f signal

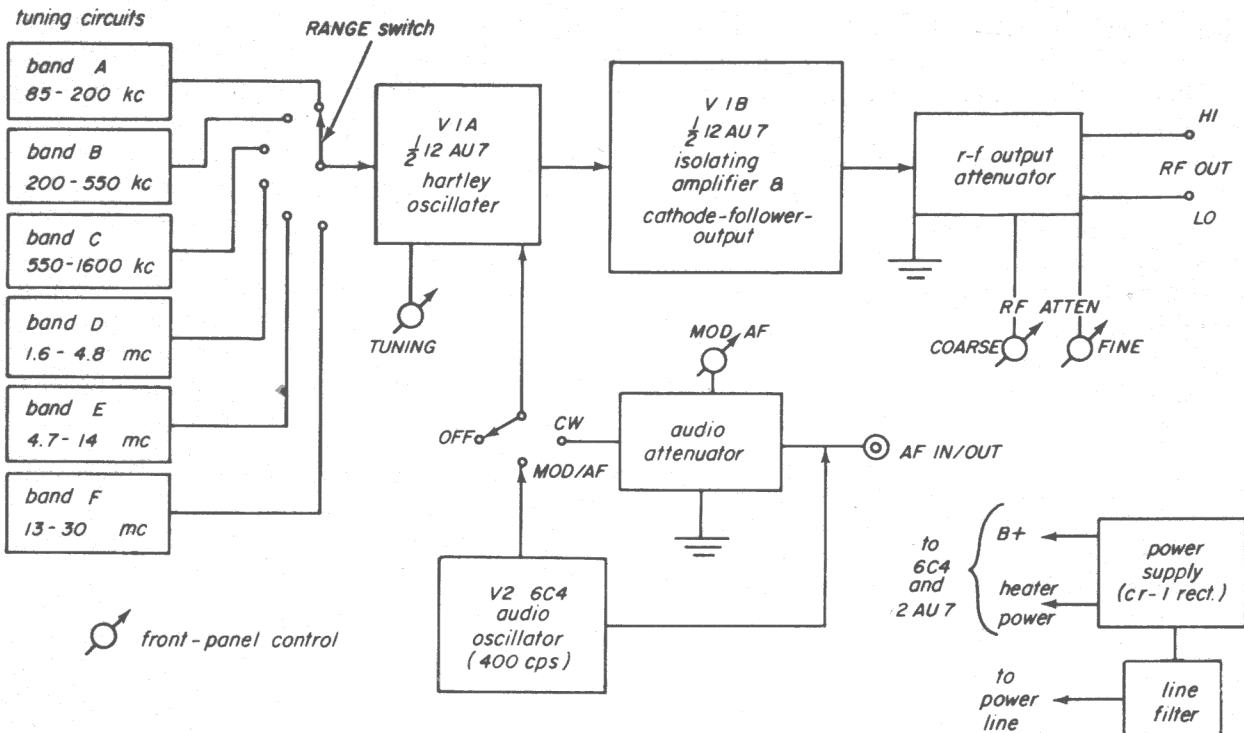
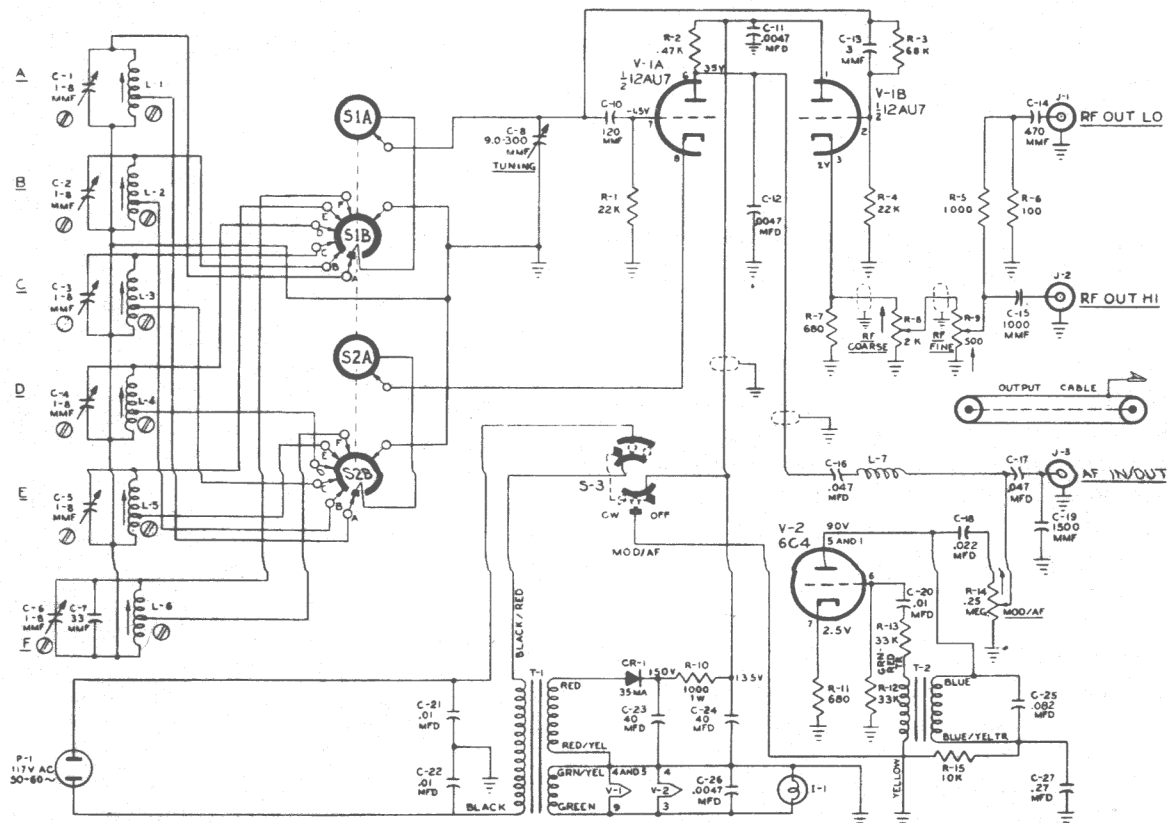


Fig. 31-2



Schematic diagram of WR-49A

Fig. 31-3

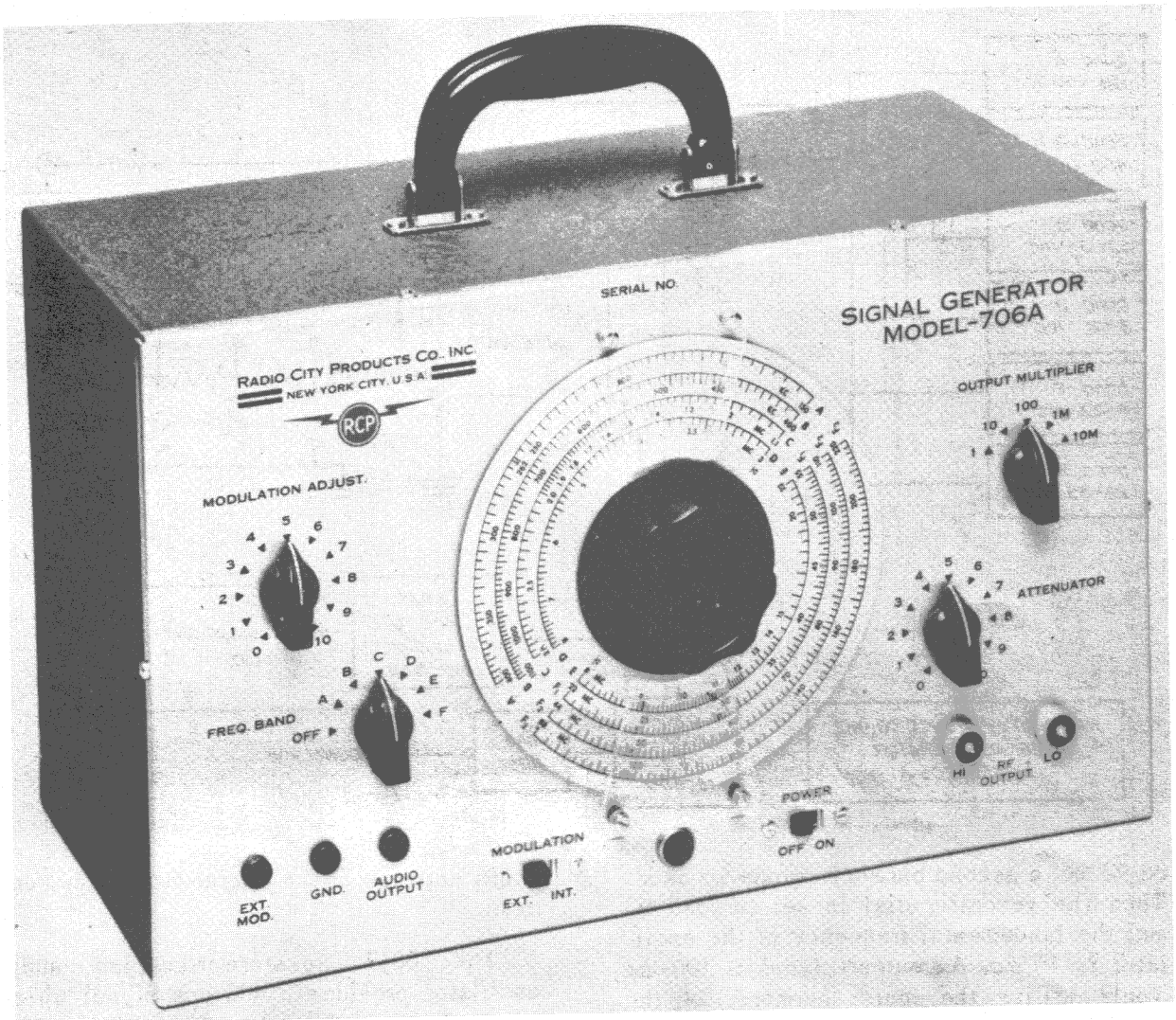


Fig. 31-4

to the output terminals and keep any d-c voltage in the test circuit from getting into the signal generator where it might damage the attenuator circuits. This arrangement permits coupling the signal directly into plate circuits without requiring the addition of external blocking capacitors.

The 6C4 supplies the 400-cps audio signal that modulates the plate of the oscillator stage. Potentiometer R_{14} serves as an audio attenuator for adjusting the audio signal fed to the audio jack, J_3 , or as a modulation adjustment when an external signal is fed to the r-f oscillator. The power supply is a straightforward half-wave rectifier type which supplies B plus and heater power to the 6C4 and the 12AU7. C_{21} and C_{22} comprise a low-pass filter to reduce r-f feedback into the power line.

Radio City Products Co. Inc., Signal Generator Model-706A. The r-f signal generator shown in Fig. 31-4 is similar in design and operation to the RCA WR-49A. Examination of the block and schematic diagrams in Fig. 31-5 and Fig. 31-6 shows that the r-f oscillator circuitry and the audio and modulation facilities are very much alike. The instruments differ primarily in the design of their output circuits.

The signal generator in Fig. 31-4 utilizes a Hartley oscillator, which tunes from 150 kc to 55 mc on fundamental frequencies. The range is divided into six bands that are selected by means of the range switch. The generator is also calibrated for r-f output on the second and fourth harmonic frequencies up to 220 mc, a useful feature for signal tracing and checking FM and TV receivers. For example, if an output signal is desired

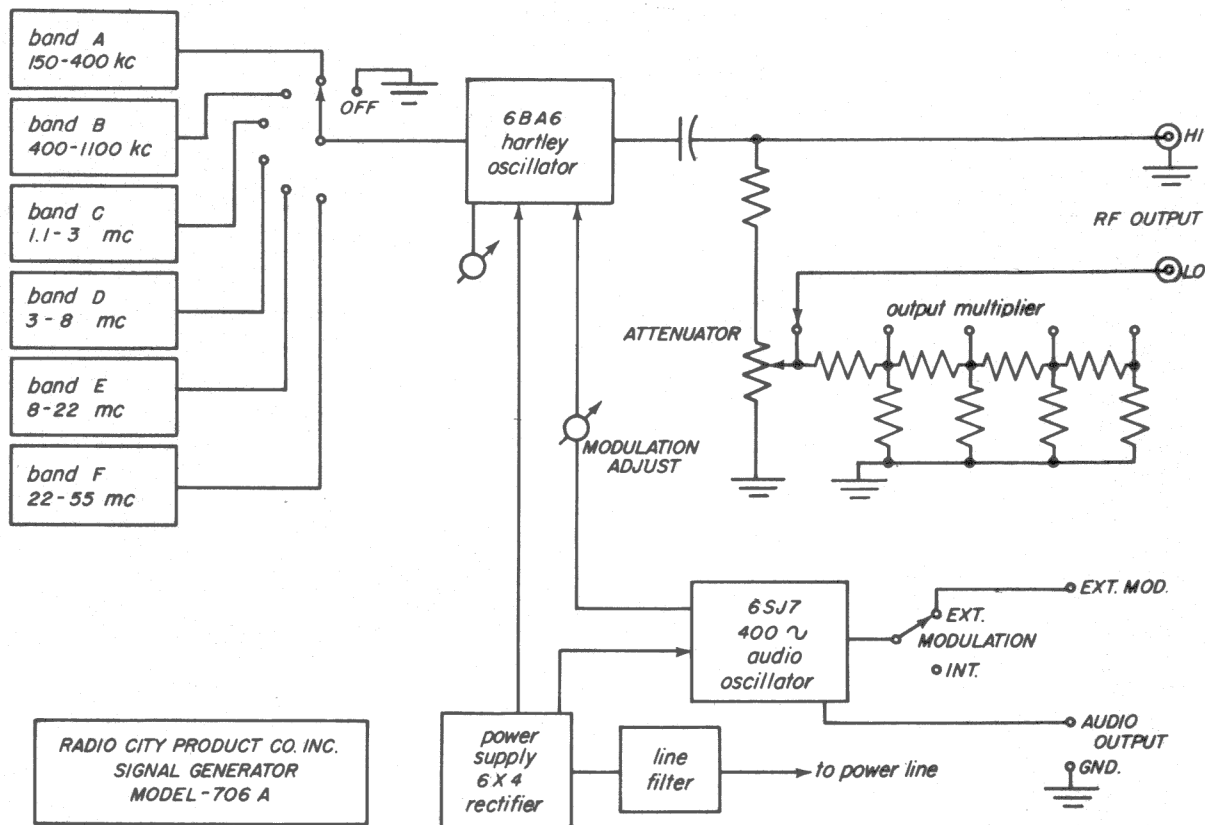


Fig. 31-5

on 92 mc, a second harmonic would be used. When the generator dial is set to read 92 mc, the fundamental frequency of the oscillator is 46 mc. An output signal at 190 mc would utilize the fourth harmonic of the oscillator running at 47.5 mc.

Output from the 6BA6 r-f oscillator is coupled through C_6 to an attenuator network, which provides for both low- and high-level output. For high output, the coaxial output cable is connected to the HI output connector so maximum r-f output can be applied to the test circuit. When the cable is connected to the LO connector, the output may be adjusted in two ways. The ladder-type step attenuator, consisting of resistors R_2 through R_9 , provides attenuation in steps having a fixed ratio. A front-panel switch, which provides the coarse control, is used to select the desired multiplier position of the step attenuator. Potentiometer R_1 is a fine-tuning control which may be used to adjust the LO output to any desired level. This control is used for all settings of the switch attenuator. Design of the ladder attenuator is such that a relatively constant impedance is maintained

at all settings of the output-attenuator controls.

The 6SJ7 transformer-coupled audio oscillator provides a 400-cps signal which is used to modulate the r-f oscillator. The audio signal is also available at a separate terminal on the front panel for use in testing audio-frequency amplifiers and other equipment. The r-f oscillator is suppressor-grid modulated and the degree of audio signal applied may be adjusted by means of the modulation control, R_{14} . The maximum modulation setting of approximately 80% is more than adequate for service applications.

When an external modulating signal is applied, the audio transformer is switched out of the circuit and the external signal is applied directly to the grid of the 6SJ7, which is connected as a straight amplifier. R_{14} is used as a modulation control for both internal and external modulation.

The power-supply section utilizes a 6X4 as a half-wave rectifier to supply B^+ voltage to the r-f and audio oscillators. Capacitors C_{16} and C_{17} comprise a low-pass filter to reduce radiation through the power line.

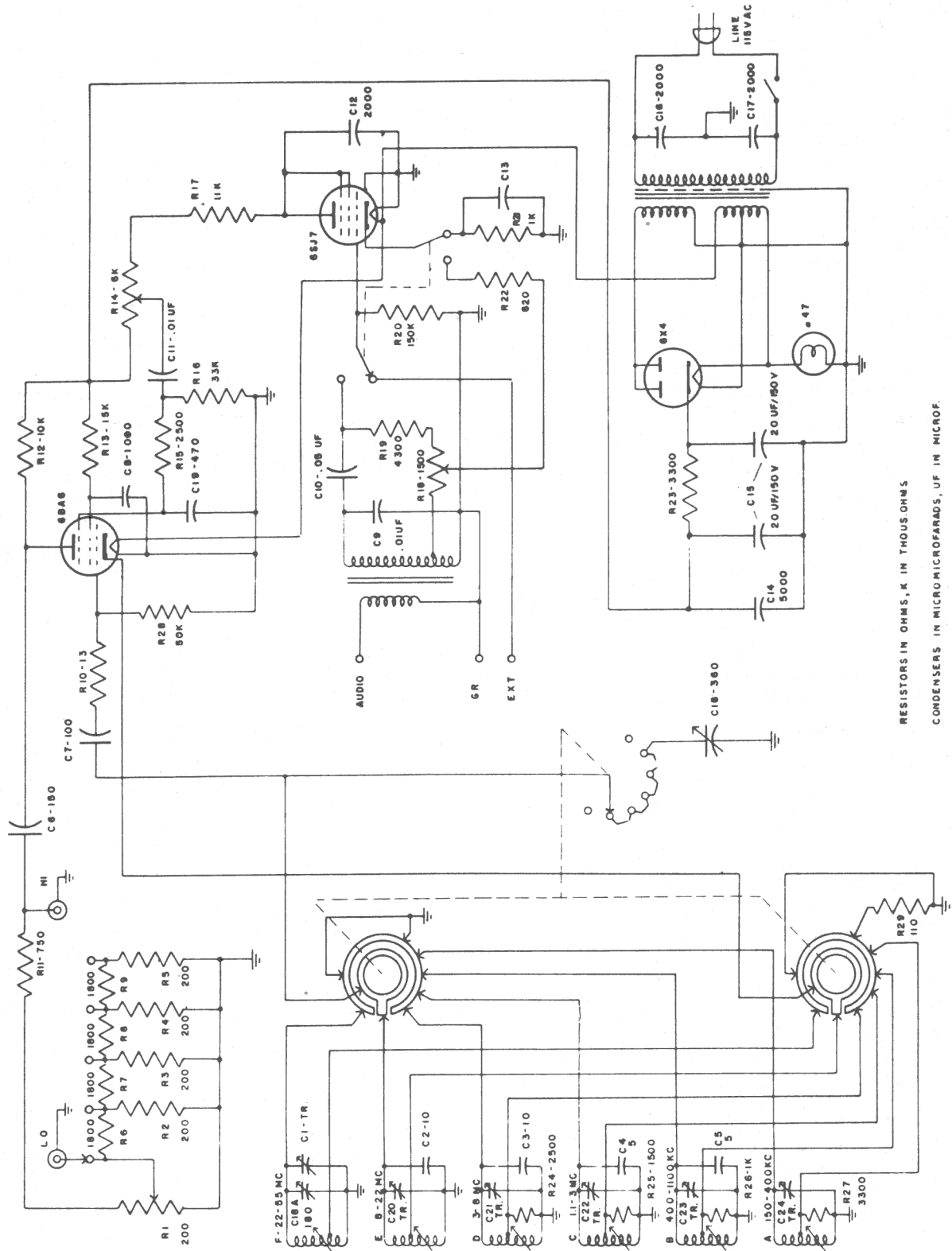


Fig. 31-6

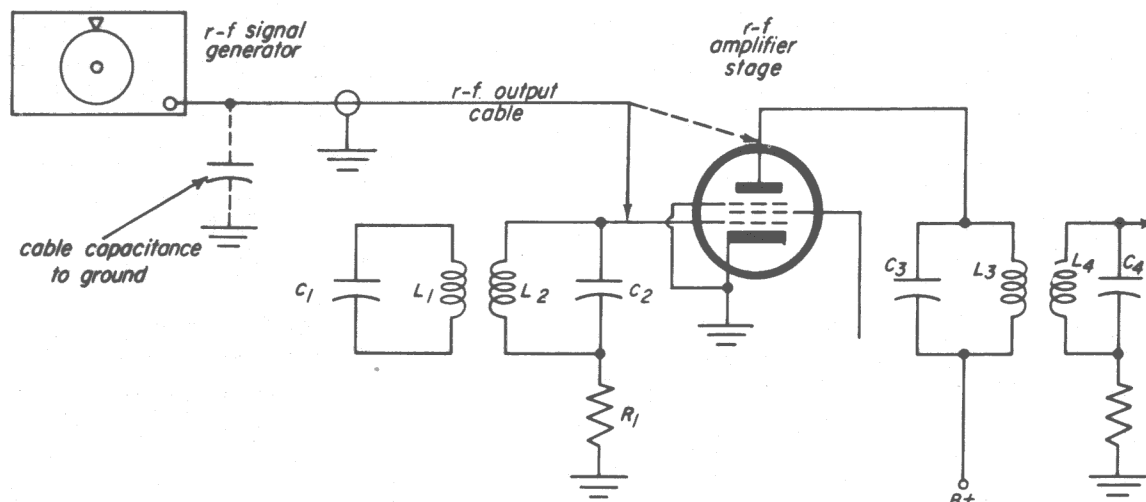


Fig. 31-7

31-3. USING THE R-F SIGNAL GENERATOR

When the signal generator is coupled to an external circuit, such as a receiver mixer or i-f amplifier, the capacitance, inductance, and resistance of the output cable and attenuator circuits become part of the test circuit. If the test circuit has a high impedance, the added capacitance of the generator cable may affect circuit operation. If the cable capacitance is high, serious detuning may result. Many high-frequency amplifiers have a grid-circuit capacitance of less than 100 μmf . The normal capacitance of an r-f output cable ranges from 50 to 75 μmf . If this capacitance is added to the tuned-circuit capacitance, as shown in Fig. 31-7, the amplifier stage may cease to function entirely.

This servicing difficulty may be overcome by use of loose coupling between the generator and the test circuit. The output lead can be placed near the circuit into which the signal is to be injected, the cable can be clipped to the insulation of the circuit lead, or a one- or two-turn loop can be wrapped around the tube. In other cases, a small mica capacitor can be connected in series with the end of the lead and the injection point. The value of the capacitor may range from 2 μmf to 50 μmf , depending upon the signal frequency and the amount of test signal required. These frequently-used coupling methods reduce the load on the test circuit and allow the stage to operate normally when the generator is connected.

It is important to avoid connecting the output cable of some r-f signal generators directly into a circuit that contains d-c voltage because the generator attenuator is not isolated from the test circuit. Such a circuit is shown in Fig. 31-8. In this example, the d-c voltage of the generator is kept out of the attenuator by means of the capacitor C_1 . When the output cable is connected into an amplifier plate circuit, however, the $B+$ voltage will appear across the attenuator resistors R_2 and R_3 , which may be burned out or damaged. This design requires that an external blocking capacitor of approximately 0.05 μf be connected in series with the output cable and the test point.

The coupling method employed may also affect frequency stability of the generator oscillator. Any self-excited oscillator, such as the Hartley circuit, is sensitive to loading affects. Unless the buffer amplifier is used to isolate the oscillator from the output circuit, tight coupling may cause shift-

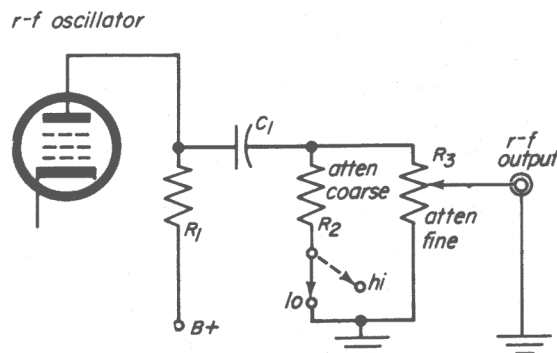


Fig. 31-8

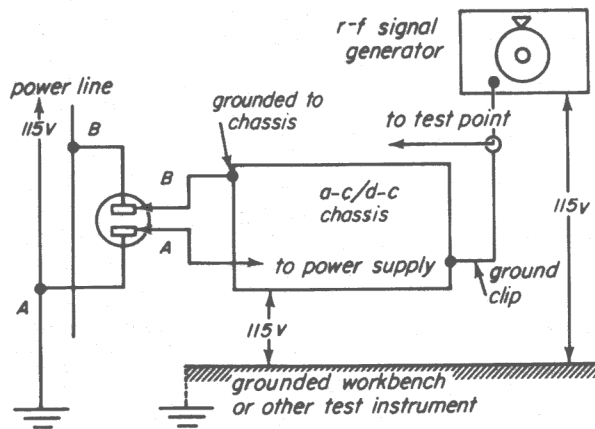


Fig. 31-9

ing of the oscillator frequency and require retuning of the generator during the test procedure. It is advisable to use the least amount of coupling required to obtain the desired test signal.

When loose coupling is used, it is frequently necessary to increase the amount of output voltage from the generator. However, this may produce excessive radiation, which can be picked up in other circuits of the receiver. For example, if a two-turn loop is used to inject a signal into an amplifier grid circuit, the loop may also inject the signal into the grid circuits of succeeding amplifier stages. This can be minimized by making the exposed lead at the end of the shielded output cable as short as possible and keeping the output signal at a low level. A low-level test signal also prevents overloading of receiver circuits.

If the shield of the output cable has a ground clip, the clip should always be grounded near the signal injection point. If no grounded shield is provided, a separate ground lead should be connected between the generator and the receiver chassis. In some cases, it may be helpful to connect the receiver to an earth ground. Proper grounding can help considerably in minimizing leakage radiation.

Whenever transformerless or a-c/d-c chassis are being tested, it is important that special precautions be observed to prevent dangerous shock hazard to the technician and to avoid burnout of equipment. In most transformerless receivers and amplifiers, one side of the power line is tied

directly or indirectly to the chassis, as shown in Fig. 31-9. In conventional wiring practice, one side of the power line is grounded, as shown by line A. If the receiver power plug is connected as shown, the hot side of the line, B will be connected to the receiver chassis. When the signal generator ground is connected to the chassis, the generator case will be hot because it is above ground by 115 volts. If the case is then connected to another test instrument or metal furniture that is grounded, a direct short will be created across the power line. To avoid these shock and short-circuit hazards, use an isolation transformer between the transformerless chassis and the power line. If a transformer is not available, observe correct polarity when connecting the transformerless chassis to the line. Check polarity with a voltmeter by taking a measurement between the receiver chassis and ground. If the line voltage is read on the meter, the power plug should be reversed in the socket before the signal generator is connected.

31-4. SWEEP (FM) SIGNAL GENERATORS

Wide bandpass circuits, such as those employed in FM and TV i-f amplifiers, require use of different alignment equipment and technique than that used in the relatively narrow bandpass amplifiers of broadcast receivers. In FM broadcasting, a bandwidth of ± 150 kc is commonly employed in transmission. In TV transmission, the picture and sound carriers are spaced 4.5 mc apart on the same channel and over-all bandpass is 6 mc. Television i-f amplifiers employ a bandwidth up to 4.5 mc. Because of these relatively wide bandpass ranges, the single-frequency peak-alignment technique employed in radio-receiver alignment is inadequate, and a system of *sweep-frequency* alignment is used in order to simultaneously observe the response at several different frequencies.

The sweep-frequency generator provides an r-f output signal that is constantly changing in frequency above and below the center frequency to which the generator is tuned. The advantages of the sweep generator can be seen by examination of the representative

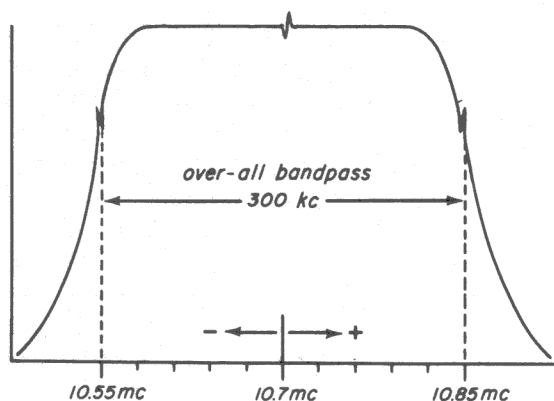


Fig. 31-10

over-all i-f response curve for an FM receiver in Fig. 31-10. The intermediate frequency of 10.7 mc is shown in the center of the curve. In order for the receiver to provide even amplification throughout the transmitted bandpass, the amplifier must have essentially flat response throughout the bandpass range. In FM transmission, this range extends approximately 150 kc above and below the center frequency. Alignment is checked by tuning the generator center frequency to 10.7 mc and adjusting the sweep-width control so the output frequency varies from 10.7 mc up to 10.85 mc, then reverses to sweep down to 10.55 mc, and back through 10.7 mc. Sweep is continuous and at such a high rate, usually 60 cps, that the resultant bandpass characteristic can be displayed as a visual trace on a cathode-ray oscilloscope. With the oscilloscope properly connected to the FM receiver (this will be described in Service Practices 33) you can watch the continuously displayed response curve on the screen while you adjust circuit components to obtain the desired curve shape.

Two methods are used to frequency-modulate the oscillator. One method, shown in Fig. 31-11, is all electronic. The frequency-determining oscillator is tuned to the desired output center frequency by means of the tuning control. A reactance-modulator tube is connected across the tank circuit of the oscillator and an a-c signal is fed to the grid of the modulator tube, causing a change in current through the tube. The change in current at the a-c frequency produces a reactive change across the oscillator tank, causing the frequency to vary continuously above and below the center frequency. The

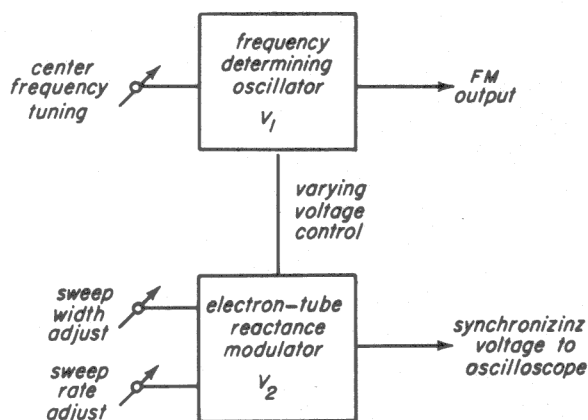


Fig. 31-11

sweep width, which is the excursion of the sweep signal from its lowest to its highest frequency, is adjusted by means of the sweep-width control, which varies the amplitude of the a-c signal fed to the modulator. With a reactance modulator, it is also relatively simple to vary the sweep rate, or the frequency at which the oscillator is swept through one complete cycle. A synchronizing voltage for the horizontal sweep of the oscilloscope is taken from the modulator.

The second method utilizes an electrical-mechanical vibrator with an attached plate that is placed close to either the capacitance or inductance of the oscillator tuned circuit. When an a-c voltage is applied to the vibrator coil, the metal plate is moved back and forth at the frequency of the driving voltage, causing the inductance or capacitance of the tuned circuit to change. Sweep width depends upon the size of the vibrating plate and upon the sweep excursion of the plate. Sweep width is varied by adjusting the amount of a-c driving voltage to the coil by means of a potentiometer or a tapped resistor and switch.

This principle is shown in the two examples of Fig. 31-12. In *a*, a low amplitude a-c voltage is applied to the driving coil through adjustable resistor R_1 . When the resistance is decreased, more voltage is applied to the coil and the sweep width is increased. The driving plate is magnetically coupled to the coil field and vibrates at the supply frequency, usually 60 cps. The unit works very much the same as a loudspeaker mechanism. In *a*, the inductance of coil L_1 is varied to change the frequency. In *b*, the

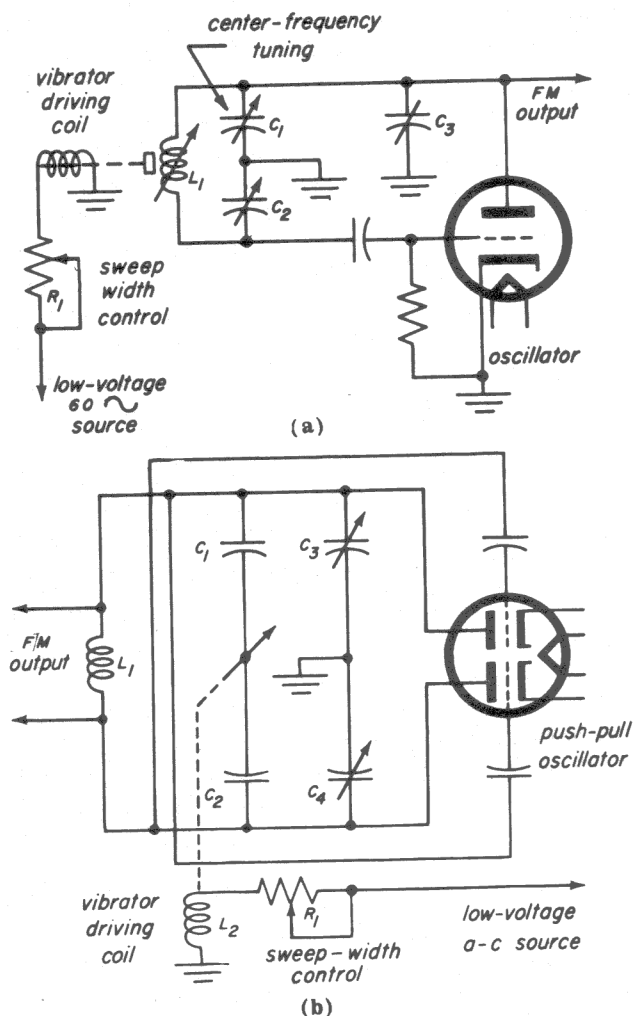


Fig. 31-12

vibrator drives a special capacitor connected directly into the tuned circuit. The construction of a typical capacitor is shown in Fig. 31-13.

Commercial practice utilizes two arrangements for producing a swept-output signal. The first, shown in Fig. 31-14a, is a straight-forward design in which a single oscillator is modulated and the swept output is fed, at the fundamental frequency, to a filter network or directly to the output-attenuator system. The second system, shown in Fig. 31-14b, utilizes two separate oscillators, one fixed and the other variable. Either the fixed or variable oscillators may be frequency modulated. The output from both oscillators is fed to a mixer amplifier, where the modulated and fixed-frequency signals are combined. A difference or beat-frequency signal is taken from the mixer. This system is similar in operation to the superheterodyne principle in radio receivers. The beat-

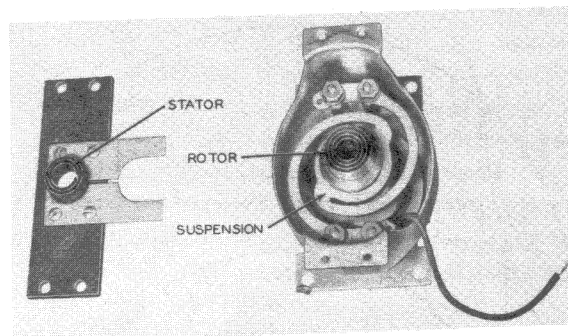


Fig. 31-13

oscillator system is used mostly in low-frequency sweep generators, where design problems make it difficult to achieve linear sweep at extremely low excursions and where it is important to maintain the same amount of sweep width over a relatively wide range of oscillator center frequencies.

In order for the sweep-response characteristics to be shown, the oscilloscope must indicate the voltage amplitude of all fre-

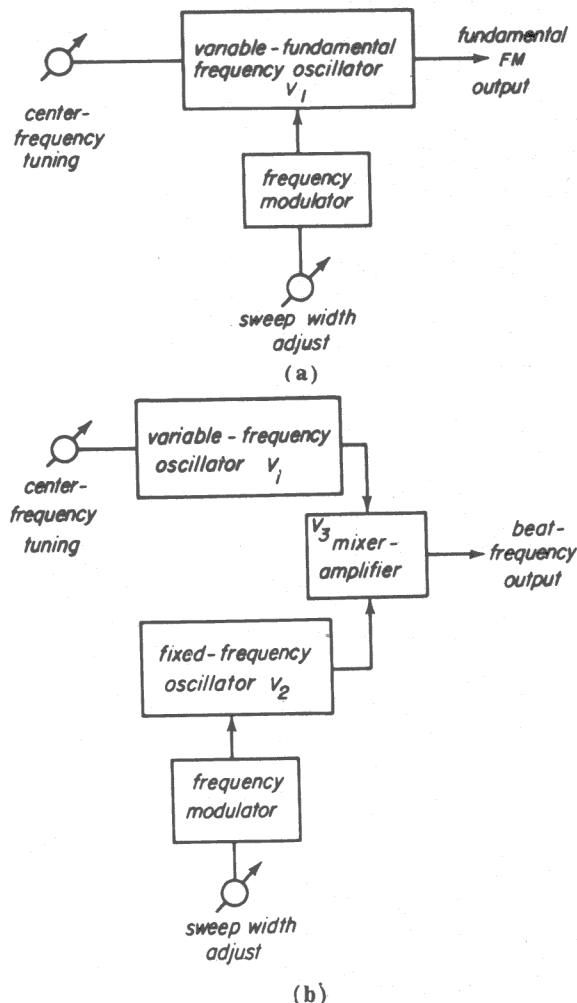


Fig. 31-14

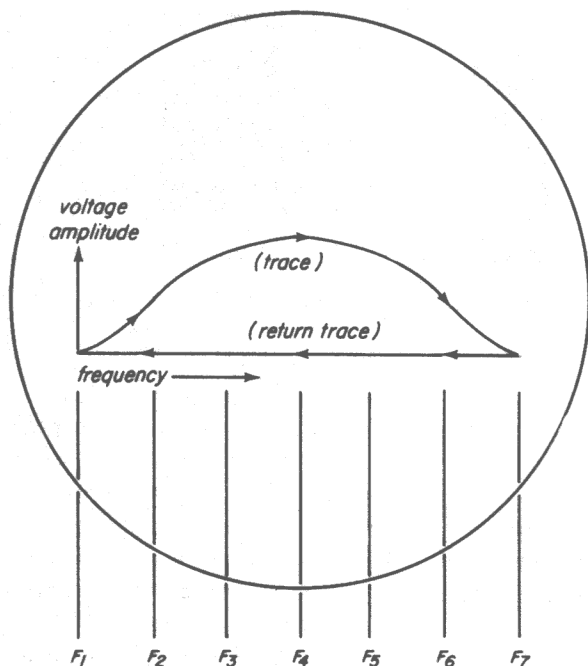


Fig. 31-15

quencies being swept and must also provide a linear time base along which the voltage amplitudes are indicated. In servicing practice, the amplitudes (response) are displayed vertically on the scope screen and the time (frequency) is displayed horizontally, as shown in Fig. 31-15.

A display of this type is made possible by the characteristics of the cathode-ray tube in the oscilloscope. An electron beam is generated in the gun structure located in the neck of the tube and is projected through a voltage-lens system onto the face of the tube. Because the inside of the cathode-ray tube faceplate is coated with a phosphor, impingement of the beam on the phosphor screen will produce a visual spot. This spot can be made to move on the face of the tube

by application of different deflecting voltages to the cathode-ray tube. If the spot is moved back and forth along a single path at a high rate, the characteristics of the human eye and the phosphor will create the picture of a continuous line or trace on the face of the tube.

The position of the beam or spot is controlled by the voltages applied to the vertical and horizontal-deflection electrodes in the tube, as shown in Fig. 31-16. When the electrodes are at the same potential, as shown in *a*, the spot will be centered. If a positive voltage is applied to electrode V_1 with respect to V_2 , as shown in *b*, the spot will be deflected upward toward vertical plate V_1 . If the positive voltage is applied to horizontal electrode H_1 , with respect to H_2 , the spot will be deflected to the left. Application of the voltage to electrodes V_1 and H_2 , in turn will cause the spot to be deflected toward electrodes V_2 and H_2 , respectively. If a positive voltage is applied to both V_1 and H_1 electrodes, as shown in Fig. 31-16*c*, the spot will be deflected to a position between these two electrodes.

It can be seen that the position of the spot depends upon the polarity and amount of voltage applied to the various electrodes. If continuously changing voltages, such as a-c signals, are applied to the vertical and horizontal electrodes, the spot will be moved continuously over the screen area.

The sweep trace from the receiver under test is displayed on the screen by utilizing these characteristics of the cathode-ray oscilloscope tube. One of these changing voltages, the r-f response signal taken from

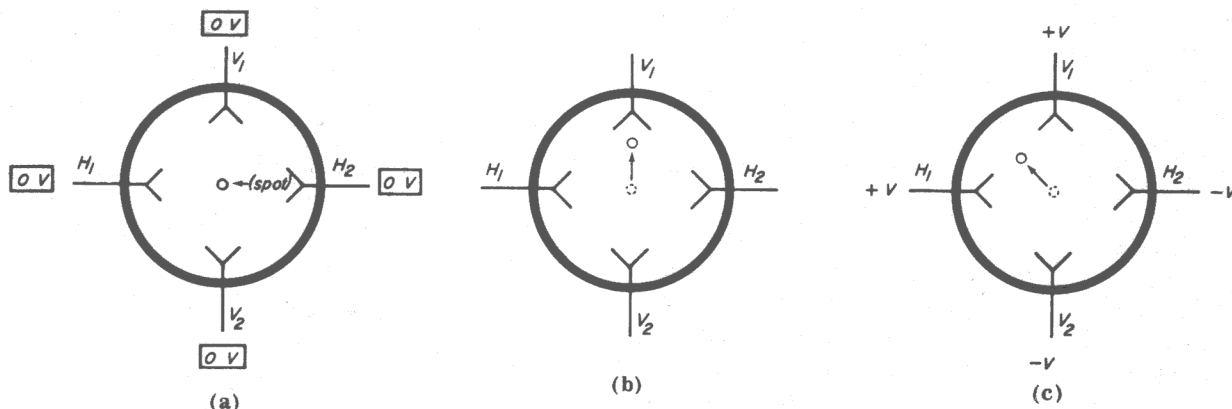


Fig. 31-16

the receiver, is applied to the vertical deflection electrodes, causing the beam to be deflected up and down.

The other voltage, an a-c signal of the same frequency as the a-c sweep-driving signal in the generator, is applied to the horizontal deflection electrodes, causing the beam to be deflected to the right and left.

In order to provide a linear display for the sweep trace, it is necessary that the horizontal deflecting voltage change at the same rate as the sweep signal from the generator. Because the sweep oscillator is swept by a 60-cps sine-wave signal, a 60-cps sine wave is applied to the horizontal deflecting electrodes, as shown in Fig. 31-17. When the sine-wave voltage is applied to the horizontal deflection electrodes, the beam will sweep from left to right (shown as A and B) on the tube. By correctly adjusting the phasing control on the generator or oscilloscope, the forward sweep of the horizontal deflecting voltage can be made to coincide exactly with the start of the forward sweep of the signal taken out of the receiver. These two starting points are shown as zero-degree points. Because the swept-response signal is applied to the vertical-deflection electrodes, the beam will be deflected vertically at the same time it is deflected horizontally. On the coincident forward sweeps, the beam will therefore follow the curved-trace path from A to B on the tube.

31-5. FEATURES AND REQUIREMENTS OF A SWEEP GENERATOR

Flat Sweep Output. Because the output from the sweep generator is used as the standard for checking tuned-circuit response, it is essential that the signal have the same voltage amplitude throughout its swept range. If the normal swept-output signal from the generator contains dips or peaks, or if the generator produces a greater voltage amplitude at the low-frequency end of the sweep excursion than it produces at the high end, the response curve shown by the test circuit or amplifier section may not be a true representation of its bandpass characteristics. Unless the generator provides es-

entially flat voltage output at maximum sweep width for any setting of the center-frequency tuning control, it cannot be depended upon for accurate alignment work. The importance of this requirement cannot be overemphasized. It is also important that certain alignment precautions, discussed further on, be observed to prevent distortion of the alignment curve.

Sweep Linearity. The sweep signal should have good linearity throughout the sweep excursion to insure a reliable picture of true circuit bandpass. Sweep linearity may be checked by superimposing accurate markers from a calibrated r-f generator on the response curve of the scope. Any cramping of markers, which is most likely to occur at either or both ends of the trace, indicates nonlinearity, either in the generator sweep circuit or in the oscilloscope.

Attenuator Circuits and Output Voltages.

Attenuator circuits are an important link between the oscillator and the output cable and must be designed well to prevent distortion of the sweep output signal. The attenuator should provide smooth, even attenuation over the range from a few microvolts to the maximum output voltage of the generator without twisting the response curve or introducing peaks or dips. Because of the

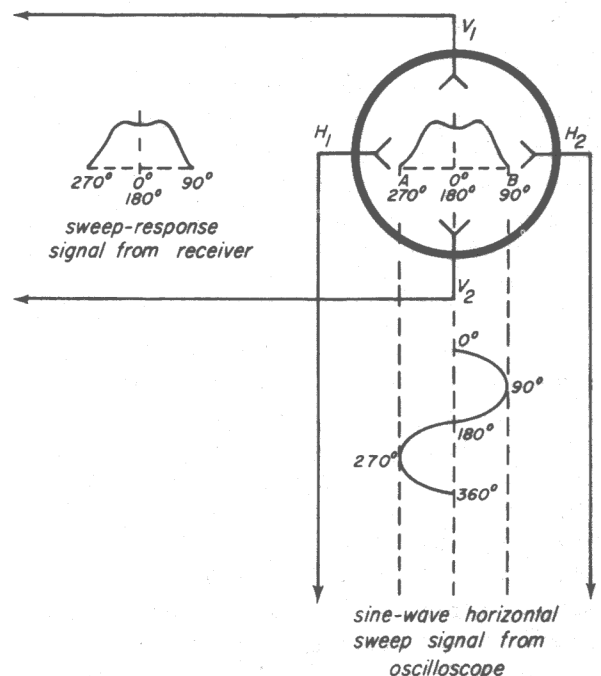


Fig. 31-17

high frequencies and wide bandwidths at which the sweep generator operates, the design of the attenuators is especially important. If the attenuator is well designed and the sweep signal is properly coupled to the test circuit, it should be possible to adjust the amplitude of the sweep signal from its maximum level to near-zero output voltage without changing the shape of the response curve, except in cases where saturation of the test circuit limits the permissible input voltage. A flat, low-level signal is often required at the antenna terminals of a receiver which has high gain. A flat, high-level signal is necessary for checking receivers and amplifiers which are badly misaligned or for checking the response of individual, low-gain amplifier stages.

Attenuators may provide a balanced or unbalanced output with respect to ground, or both, depending upon the frequencies covered and the nature of the application for which the generator is designed. Either a continuously adjustable control or a pre-fixed switch attenuator, which provides attenuation in steps having a fixed ratio, may be used.

Adjustable Sweep Width. The sweep generator should be equipped with a control to permit adjusting the width of the swept signal at any frequency throughout the oscillator tuning range. If a potentiometer control is used, it is possible to adjust the sweep to any desired width within the sweep range. Switch controls provide for changing the width in steps of several kilocycles or megacycles, or in steps which are a percentage of the center frequency. A combination of both types of controls is used on some generators.

With many sweep generators, it will be found that the sweep-frequency range at any given setting of the sweep-width control will increase as the oscillator frequency is raised. In general, it is advisable to set the sweep-width control to the position that provides a slight amount of sweep overlap of the circuit bandpass. A sweep generator that can deliver a swept signal equal to approximately 10% of the center frequency is generally adequate for service work.

Frequency Coverage. Because commercial sweep generators are usually designed for only one or two types of servicing, they do not cover all the frequencies encountered in radio and TV work. For the applications listed in Table A, a generator should be able to cover the output frequencies shown.

TABLE A			
Application	R-F Range	I-F Range	Video and Color Range
AM Receivers	500-1,600 kc	100-500 kc	
FM Receivers	85-110 mc	10.7 mc	
VHF TV Channels 2-6	54-88 mc	4-50 mc	0-4.5 mc
VHF TV Channels 7-13	174-216 mc	4-50 mc	0-4.5 mc
UHF TV Channels	470-890 mc	4-50 mc	0-4.5 mc

Output Cables. Output cables should not be taken for granted. Their design and application directly affect the efficiency and accuracy of alignment.

The output cable transfers the sweep signal from the generator to the test circuit without distortion or attenuation. The cable should present a relatively constant impedance to the generator and should work into specified test-circuit impedances without upsetting circuit frequency response and gain. To meet this requirement, the sweep generator may be equipped with two different output circuits. The generator cable must be able to work into circuits of FM and TV receivers, which commonly employ 300-ohm input circuits at the front ends, without upsetting the circuit impedance and changing the frequency response and gain characteristics. For receivers which employ other input impedances, it may be necessary to construct simple resistance pads which are inserted between the output cable and the antenna terminals. The construction of such pads is described by the generator manufacturer in the instruction book.

R-F mixer and i-f amplifier circuits generally have a much higher grid-circuit impedance and, consequently, require a higher output impedance at the generator. An unbalanced output circuit that can work

into impedances of 100,000 ohms or more is generally included in the generator. These considerations are of most importance in the servicing of TV receivers that operate at relatively high frequencies and utilize wide bandwidths.

It is essential, however, that the output cable be thoroughly shielded throughout its length to prevent excessive radiation and pickup of undesired r-f fields. Wherever possible, the output cable supplied with the sweep generator should be used for alignment.

Shielding and Filtering. As the operating frequency of the sweep generator is increased, leakage and radiation become increasingly critical problems. In the *vhf* and *uhf* regions, double and triple shielding of r-f sections is common practice. Instrument-cases, signal-carrying leads, and output cables must be tightly shielded and grounded to prevent even small amounts of signal from getting into the high-gain circuits of FM and TV receivers where they can complicate alignment. Examination of the generator power-line filters shows that two- and three-section low-pass filters are used to reduce coupling through the power line.

Filtering is especially important in beat-frequency types of generators to prevent transfer of harmonic and spurious signals into the output circuit. Many of the beat-frequency generators employ high Q, band-pass filters at the output of the mixer. Unless spurious signals, which might be generated in the complex circuits of beat-frequency oscillators, are eliminated, they may show up as "birdies" or pips (see Fig. 31-10) on the oscilloscope trace and be easily confused with calibrating markers.

Blanking, Phasing, and Oscilloscope Connections. Because the sweep generator must be used in conjunction with an oscilloscope to provide a visual indication of response, it is necessary to synchronize the sweep of the generator oscillator with the sweep of the oscilloscope. This is accomplished by feeding part of the sinusoidal sweep-driving voltage from the generator to the horizontal- or sync-input terminals of the oscilloscope. With the generator and the

oscilloscope sweeping at the same rate, it is also necessary that the two sweeps coincide *in phase*. Therefore, the generator should have a phase control to permit adjustment over a range of approximately 150 degrees.

Return-trace blanking must also be provided to cut off the return-trace of the generator sweep. A square-wave pulse, formed by a special circuit in the sweep generator, is applied to the sweep oscillator at the maximum excursion point to cut off the oscillator tube during the return sweep. Blanking is necessary to provide a zero-reference line on the oscilloscope screen for making amplitude measurements. Blanking is not usually provided on service-type oscilloscopes and must, therefore, be included in the sweep generator. The generator should also be provided with a switch to permit removal of the blanking signal for phase adjustments.

The Hickok Model 288X Signal Generator.

The Hickok Model 288X signal generator (Fig. 31-18), combines a number of features which give it considerable flexibility in servicing AM, FM, and TV receivers. The generator is also useful in checking performance of audio equipment. The generator will provide as an output an unmodulated r-f signal from 100 kc to 110 mc.

It will also provide as an output an amplitude-modulated r-f signal from 100 kc to 110 mc modulated by either an internal 400-cps signal or by an external source of a different frequency. A third output is a frequency-modulated r-f signal as follows:

1. Adjustable center frequencies from 100 kc to 110 mc with adjustable sweep width from 0 to 450 kc, depending upon the center frequency. Sweep rate may be 60 to 400 cps.
2. An FM output signal at 50 mc with adjustable sweep width from 0 to 450 kc at a sweep rate of 60 cps.
3. An FM output signal at 50 mc with adjustable sweep width from 0 to 150 kc at a sweep rate of 400 cps.
4. An FM output signal at 1,000 kc with adjustable sweep width from 0 to 30 kc at a sweep rate of 60 cps.



Fig. 31-18

The audio output signal provided is fixed at 400 cps or an adjustable output signal from 20 to 15,000 cps. The generator also provides crystal controlled output signals on fixed frequencies as follows:

1. 100 kc, unmodulated. Usable to 15,000 kc on harmonics.
2. 100 kc, amplitude modulated. Usable to 15,000 kc on harmonics.
3. 1,000 kc unmodulated. Usable to 125 mc on harmonics.
4. 1,000 kc amplitude modulated. Usable to 125 mc on harmonics.

The Hickok Model 288X Signal Generator also has provision for applying external modulation up to 15,000 cps. A calibrated output attenuator is provided for both r-f and audio output. A decibel meter is included for use in audio measurements.

The functions of front-panel controls shown in Fig. 31-18 are as follows:

The **FREQUENCY MODULATED SWEEP** is a dual-purpose control used to apply power to the generator and to control the width of the sweep signal when the generator is set up for FM output.

The **BAND SELECTOR** is a 10-position

control that selects various frequencies from 100 kc to 110 mc, fixed output at 100 kc or 1,000 kc, or audio output.

The FREQUENCY ADJUSTMENT is used to select a specific frequency within the tuning range selected by the BAND SELECTOR switch.

The OUTPUT CONTROL, a potentiometer, adjusts output level of r-f and audio signals.

The OUTPUT MULTIPLIER is a combination switch which serves as a fixed-ratio attenuator for the r-f output or selects the type of audio or FM output desired.

The FM-AM SELECTOR selects the type of AM output desired, or fixed FM output at 1,000 kc or 50 mc.

The OUTPUT SELECTOR is a five-position switch used in conjunction with other controls to select the type of r-f and audio output desired.

The VARIABLE AUDIO FREQUENCY sets the frequency of the audio-output signal from 0 to 15 kc.

The SYNCHRONIZED SWEEP VOLTAGE provides an a-c output voltage to permit synchronizing an oscilloscope sweep oscillator with the sweep oscillator in the generator.

The EXTERNAL MODULATION is used for feeding an external AM or FM modulating signal to internal oscillators.

The EXTERNAL MODULATION is where an external signal is fed in to produce AM or FM output modulated by the external source.

The OUTPUT JACK is for permanently attaching the output cable, which serves for both audio and r-f output signals.

The DECIBEL METER terminals are used in conjunction with the adjacent GROUND terminal for measuring the level of audio signals.

A block diagram of the Hickock Model 288X Signal Generator is shown in Fig. 31-19,

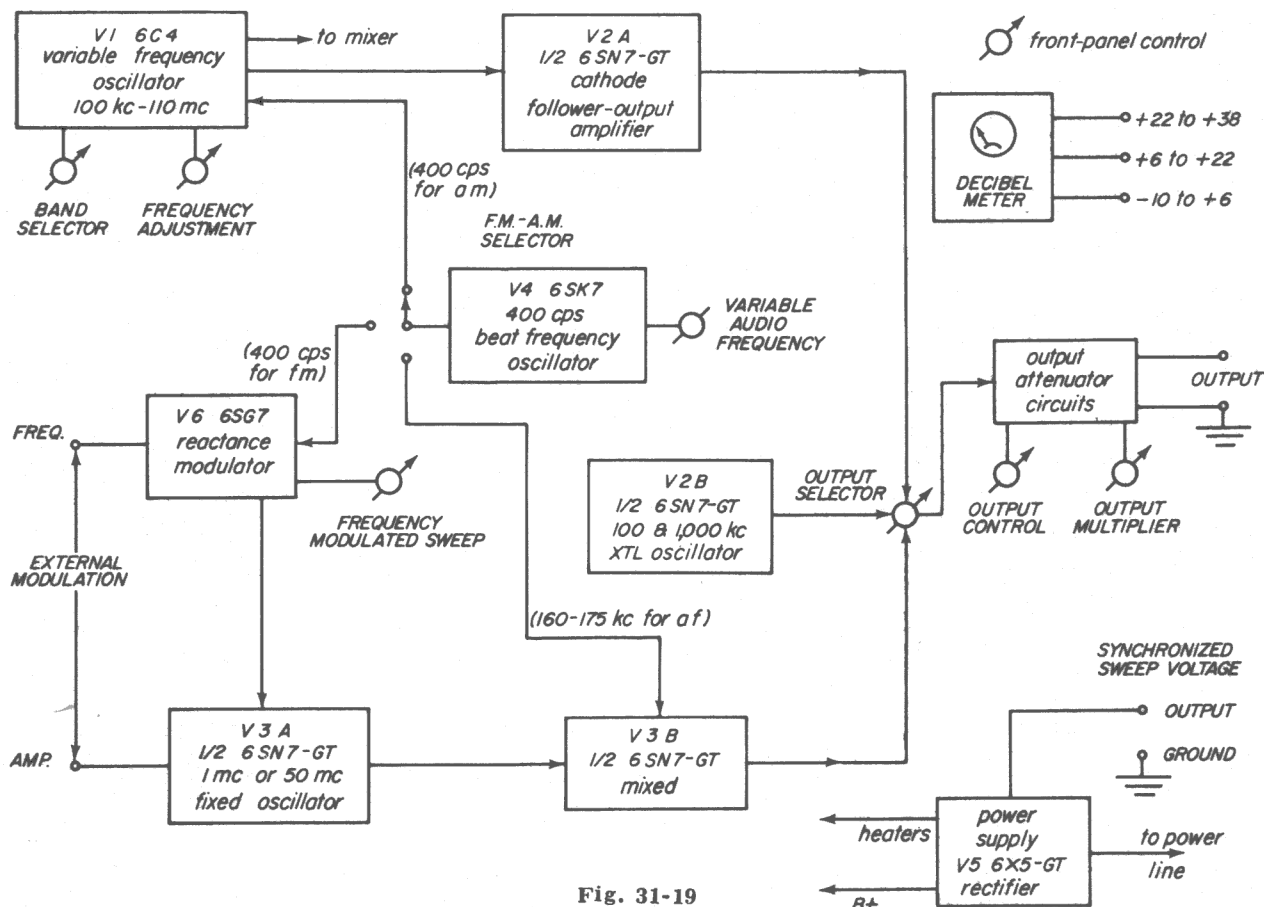


Fig. 31-19

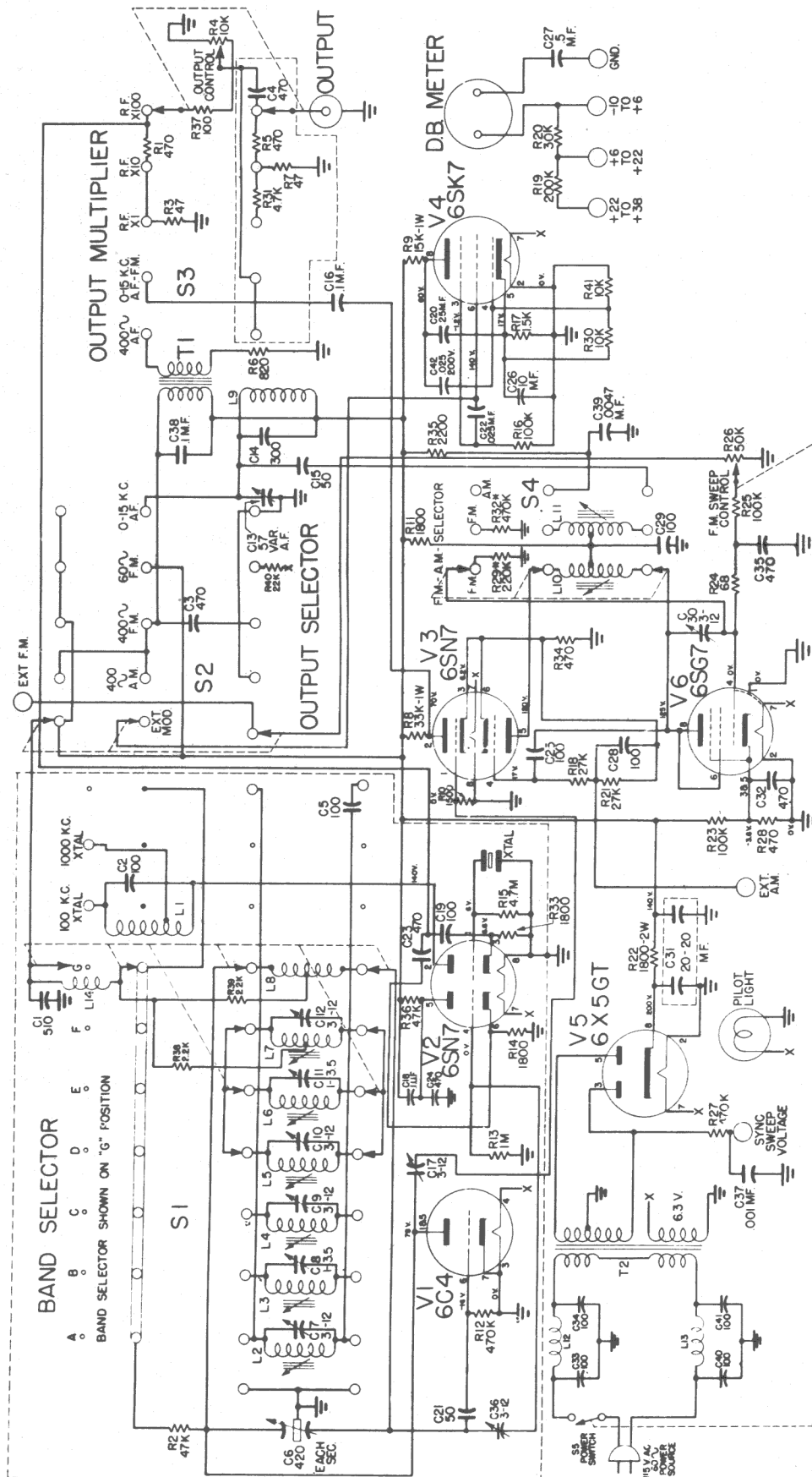


Fig. 31-20

and the schematic diagram is shown in Fig. 31-20.

The variable-frequency oscillator, V_1 , is a Colpitts-type oscillator tunable from 100 kc to 110 kc, and is used for a number of important functions in the generator. It serves as a straightforward r-f oscillator which can be amplitude modulated at 30 percent by an internal 400-cps oscillator, V_4 , or by an external audio signal up to 15 kc. It is also used in conjunction with V_{3A} , a fixed 1-mc or 50-mc oscillator, to provide frequency-modulated output over the range from 100 mc to 160 mc. The signals are mixed in the V_{3B} mixer stage. When the generator is set up for audio-frequency output, the signal from the main variable-frequency oscillator is mixed with a signal from the beat frequency oscillator, V_4 , to produce a variable audio signal from 0 to 15 kc. For audio output, the main variable-frequency oscillator is set to its lowest frequency range, 100 to 300 kc. Mixing of the two signals is accomplished in the mixer stage, V_{3B} .

Frequency modulation is accomplished in the Hickok Model 288X by a reactance modulator stage, V_6 , which modulates V_{3A} , a fixed frequency oscillator, which will provide an FM output signal at 1 mc or 50 mc or, when the output signal is combined with the r-f signal from V_1 in the mixer stage, an FM signal at any point in the tuning range from 100 kc to 160 mc. The sweep-modulating signal is supplied by oscillator stage V_4 , which supplies output directly to the reactance modulator.

The crystal-oscillator stage, V_{2B} functions independently of the other sections of the generator and supplies accurate signals at harmonics of the 100- and 1,000-kc crystals. Output from this stage, as well as output from the cathode-follower amplifier and mixer stages, is fed into the attenuator circuits, which provide for adjustment of all output signals to the desired voltage level. The decibel meter also is independent of other circuitry and can be used to measure the audio output from the generator or to measure an audio signal from an external source.

In application of the sweep generator, the operating precautions and suggestions

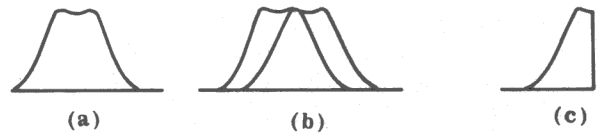


Fig. 31-21

focus on one important consideration—avoiding distortion of the sweep output signal. Distortion includes tilt, introduction of bumps and dips, clipping, premature blanking cutoff, improper phasing, and voltage attenuation. The general suggestions given here will help to avoid these pitfalls.

Excessive loading of the test circuit by the output cable is discussed in the discussion of r-f signal generators. Observe the precautions discussed when using the sweep generator. During sweep alignment, the sweep-signal level should be kept as low as possible. The necessary gain can be supplied by the vertical amplifier of the oscilloscope. The oscilloscope gain control should be adjusted to provide the required amplitude of the waveshape. This practice avoids overloading of receiver stages and resultant distortion of the response curve due to clipping by overdriven amplifier tubes.

With the sweep generator and the scope properly connected to the receiver, blanking and phase adjustments should be made before alignment adjustments are attempted. The phasing control should be set with blanking off, then blanking should be applied. Effects of different setting of these controls are shown in Fig. 31-21.

A representative response curve obtained when phasing is correct and blanking is applied is shown in Fig. 31-21a. The horizontal base line is obtained by blanking; correct phasing of the generator and oscilloscope sweep circuits is indicated by the position of the response curve in the center of the base line. In Fig. 31-21b, two images are produced; one by the forward sweep and one by the reverse sweep of the generator signal. No blanking is used. The double image is caused by improper setting of the phasing control. If a marker is injected into the test circuit, two markers will appear—one on each response curve. When the phase control is set properly, the two images will coincide. This adjustment should al-

ways be made before blanking is applied. Improper setting of the phasing control with blanking applied can produce the cutoff response curve and misplaced base line shown in Fig. 31-21c. Unless this condition is recognized before alignment is attempted, an erroneous interpretation of the circuit alignment is possible.

RC circuits are more generally employed and offer considerable flexibility in design. A wide range of coverage, extending from the low audio range well into the r-f region is possible with RC oscillators. Wide frequency range can be covered by use of individual frequency bands, requiring only the switching of resistance or capacitance values.

Many service-type and laboratory variable-frequency audio oscillators utilize a particular type of RC oscillator circuit—the Wien bridge—to generate the audio signal. The basic Wien-bridge circuit is shown in Fig. 31-22. The Wien-bridge audio oscillator has a number of distinct advantages over other types of RC and LC oscillators, as follows:

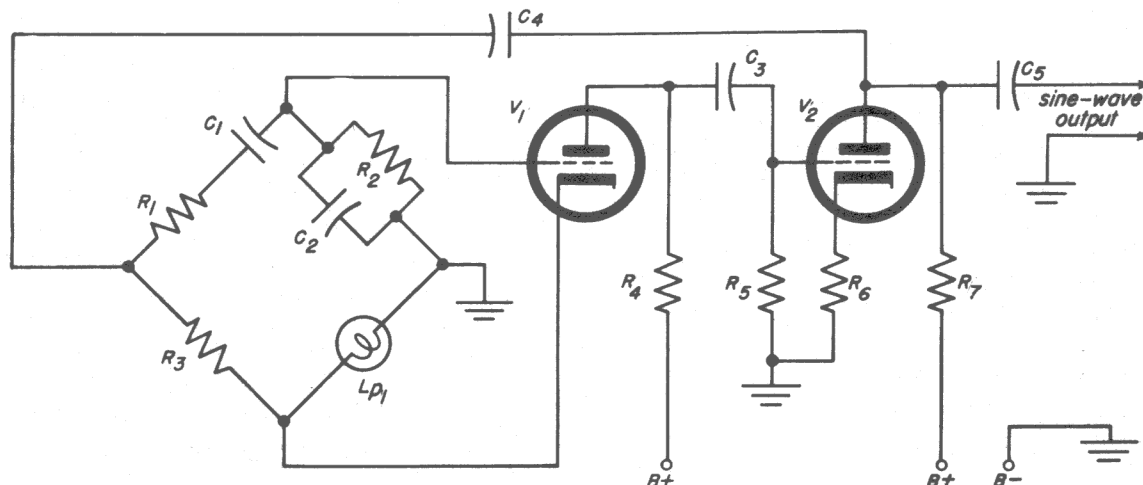
1. It can be designed to provide output over a wide frequency range.
2. The output waveshape is very near to a pure sine wave (sinusoidal).

3. Frequency stability is excellent.

4. Amplitude of the output voltage is relatively constant over a wide frequency range.

These advantages are inherent in the circuit, which operates as follows: Looking at Fig. 31-22, V_1 is the oscillator tube and V_2 serves as phase inverter. The signal generated by V_1 is amplified by V_2 and fed back in phase to the grid of V_1 through the voltage divider consisting of R_1 , C_1 , R_2 , and C_2 . Because this feedback is in phase, oscillations will be amplified and sustained in the circuit. The values of these components are chosen to provide a frequency-selective circuit that will shift the phase and attenuate all feedback frequencies except the signal frequency, F_o . Therefore, the amount of feedback from V_2 is greatest at frequency F_o . Frequencies higher or lower than F_o will have reduced amplitude and will be insufficient to sustain oscillation in V_1 .

The feedback signal from V_2 is also applied to the cathode of V_1 through the voltage divider formed by R_3 , and the lamp, L_{p1} . Because no phase shift occurs across this network, which is essentially pure resistance, feedback to the cathode circuit is degenerative, and the amplitude of the feedback voltage at the cathode will be relatively constant for all frequencies of V_1 .



basic Wien-bridge oscillator

Fig. 31-22

Consequently, at any frequency other than F_0 , the negative feedback applied to the cathode is greater than the positive feedback applied to the grid, resulting in attenuation of all output frequencies of V_1 except F_0 .

A unique feature of the Wien-bridge circuit is the use of the lamp, L_{P1} , which serves as a nonlinear resistance, in the cathode circuit. When the current through the lamp increases, the lamp filament becomes hotter, making the resistance increase, resulting in generation of more negative feedback and a reduction in the gain of V_1 . Because this resistance varies with the output frequency and signal amplitude, the output voltage from the oscillator is held at nearly constant amplitude. By maintaining a relatively fixed signal amplitude, the lamp also helps to prevent distortion of the sinusoidal signal.

Calibrated frequency markers from a marker generator are often used to check the bandpass and to identify specific frequencies on the displayed response curve. If the marker signal is injected into the same test point used for the sweep signal, the marker voltage should be kept low to avoid distorting the response curve on the oscilloscope. A high marker voltage will produce a curve marker, which has a relatively high amplitude but can also cause the base of the marker to spread out and possibly obscure the response curve.

31-6. AUDIO-FREQUENCY SIGNAL GENERATORS

The audio-signal generator, as well as the square-wave generator, is finding increased use in servicing high-fidelity amplifiers, preamplifiers, tone-control circuits, loudspeaker systems, and many other audio devices. Because these instruments provide output over the entire audio range, they can be used in running frequency-response tests and for troubleshooting by signal injection. The relatively low cost and flexibility of these generators make a desirable and highly useful instrument in any service shop. On the audio-service bench they are indispensable.

Requirements of the Audio-Signal Generator. The characteristics and features of high-fidelity equipment set the performance standard for the audio generator. For frequency-response checking, the generator should be able to deliver an output signal over a frequency range from approximately 20 cps to 100 kc. Output down to 20 cps is necessary for checking performance of low-frequency woofers, speaker enclosures, and horns. Output up to 100 kc is necessary for checking wide-range and ultra-linear amplifiers, such as the MacIntosh and Williamson.

The output waveshape from the audio generator should be as sinusoidal as possible. This requires that hum and harmonics be eliminated or kept at an extremely low level. A clean signal is necessary for making comparative waveshape checks at the output of an audio amplifier. The generator should also be able to work into a variety of load resistances ranging from a few ohms for speaker voice coils up to a megohm or more for high-grain input stages. The output and attenuator circuits should be designed to provide relatively flat output at any output impedance and frequency to avoid the necessity for resetting the attenuator control whenever the output frequency is changed. Although output impedance matching requirements are not critical in audio work, the output circuit and cable should be shielded to prevent "spraying" the signal into circuitry adjacent to the injection point.

Audio-Oscillator Circuits. The different circuit arrangements which can be used to generate an audio frequency signal can be classified into two groups—inductance-capacitance (LC) circuits and resistance-capacitance (RC) circuits. Use of LC oscillators in service-type generators is confined mostly to oscillators which operate at a fixed output frequency. The audio oscillators used in the RCA WR-49A R-F Signal Generator (Fig. 31-3) and the Radio City Products Co. Inc. Model 706A generator (Fig. 31-6) are examples of LC oscillators.

Some types of very low-frequency audio oscillators, which find most use in laboratory

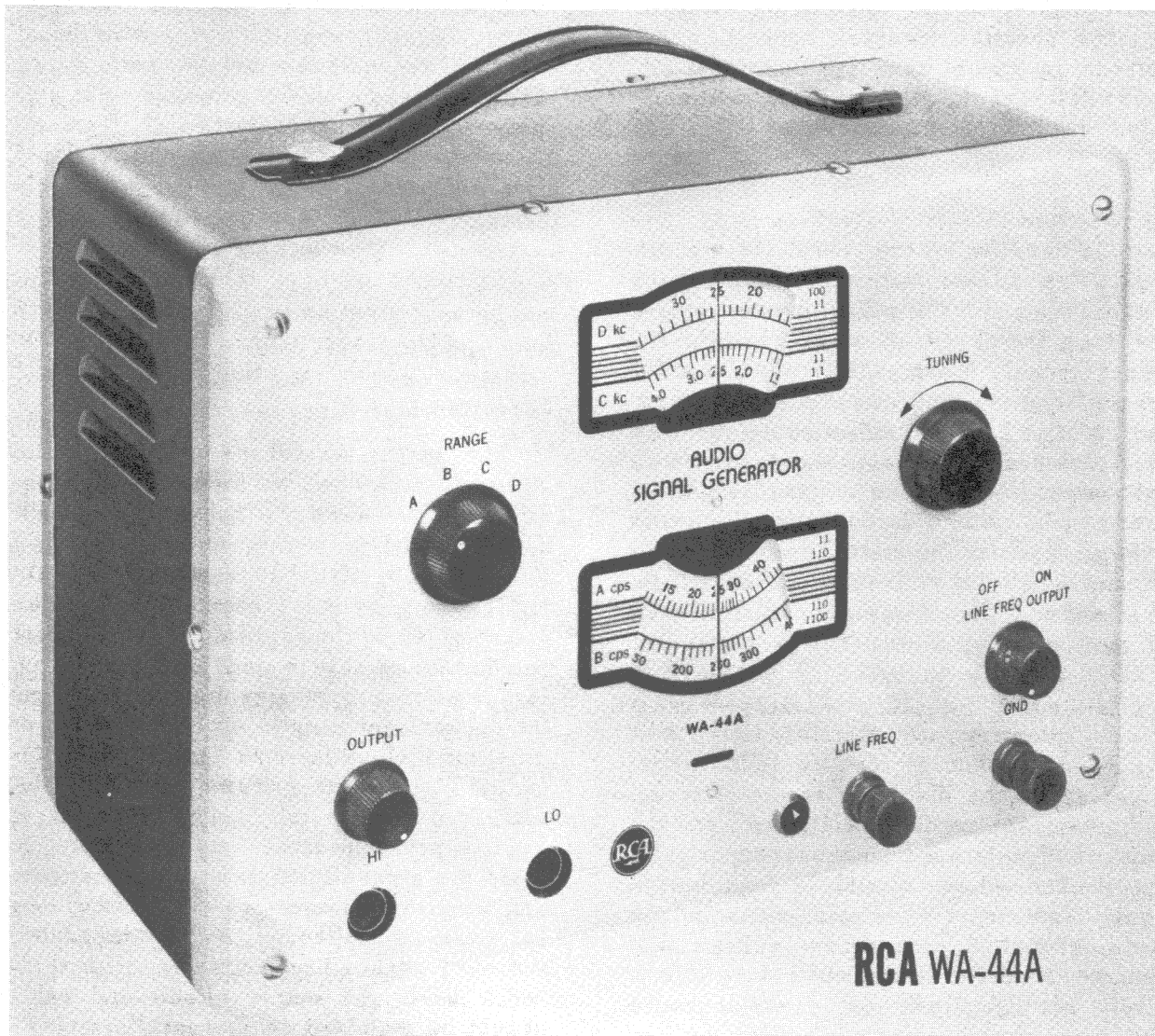


Fig. 31-23

applications, utilize a beat-frequency (heterodyning) principle similar to that employed in generating low frequency r-f signals. A fixed-frequency and a variable-frequency oscillator are used and the output signals from both oscillators are fed into a mixer stage where they are beat together and the difference frequency extracted. With this arrangement, it is possible to obtain beat output frequencies down to less than one tenth of one cycle per second.

The RCA WA-44A Audio Signal Generator.

A representative audio signal generator, the RCA WA-44A, is shown in Fig. 31-23. The WA-44A provides sinusoidal output signals from 11 to 100,000 cps in four frequency ranges. Amplitude variation of the

output voltage is less than -1 db throughout the frequency range and total-harmonic distortion does not exceed 2% over the range from 30 cps to 15 kc. Hum modulation of the output signal is kept to less than 0.1% of the rated output voltage. Output is taken through a continuously adjustable attenuator circuit. Provision is made for coupling to both high- and low-impedance test circuits.

The functions of controls and terminals on the WA-44A are as follows:

THE OFF-ON LINE FREQ. OUTPUT CONTROL applies power and controls amount of line-frequency voltage to the LINE FREQ. terminal.

The RANGE control selects one of the four frequency ranges.

The TUNING control is used in conjunction with the RANGE switch to select the exact output frequency.

The HI connector is used when application requires an output voltage of 2.5 volts or more or when load impedance is 100,000 ohms or higher.

The LO connector is used when the application requires an output voltage of 2.5 volts or less or when the load impedance is 1,500 ohms or higher.

The OUTPUT control adjusts the amplitude of the output voltage available at both the HI and LO connectors.

The LINE FREQ. control provides a line-frequency a-c voltage adjustable up to 6 volts. This feature is convenient for making intermodulation tests, which require two audio signals, one at a low frequency and the other at a high frequency.

This signal generator differs in operation from Wien-bridge oscillators, although it utilizes a selective feedback system to sustain oscillation and preserve good output waveshape. The block diagram of the signal generator is shown in Fig. 31-24 and the schematic in Fig. 31-25. A simplified version is shown in Fig. 31-26.

The WA-44A functions as follows:

V_1 and V_2 comprise a phase-shift oscillator stage of special design whose output is fed to a straightforward output amplifier stage, V_3 . The OUTPUT control, potentiometer R_{11} , controls the amount of signal fed to the output amplifier. Both high- and low-output impedances are provided. The high-impedance output terminal is coupled to the plate of the 6AQ5 (V_3) through blocking capacitor C_5 , which is large enough to pass low-frequency signals. Output for low-impedance loads is taken from the low-impedance cathode circuit through capacitor C_6 . Use of these coupling capacitors eliminates the necessity for connecting external blocking capacitors to the output cable.

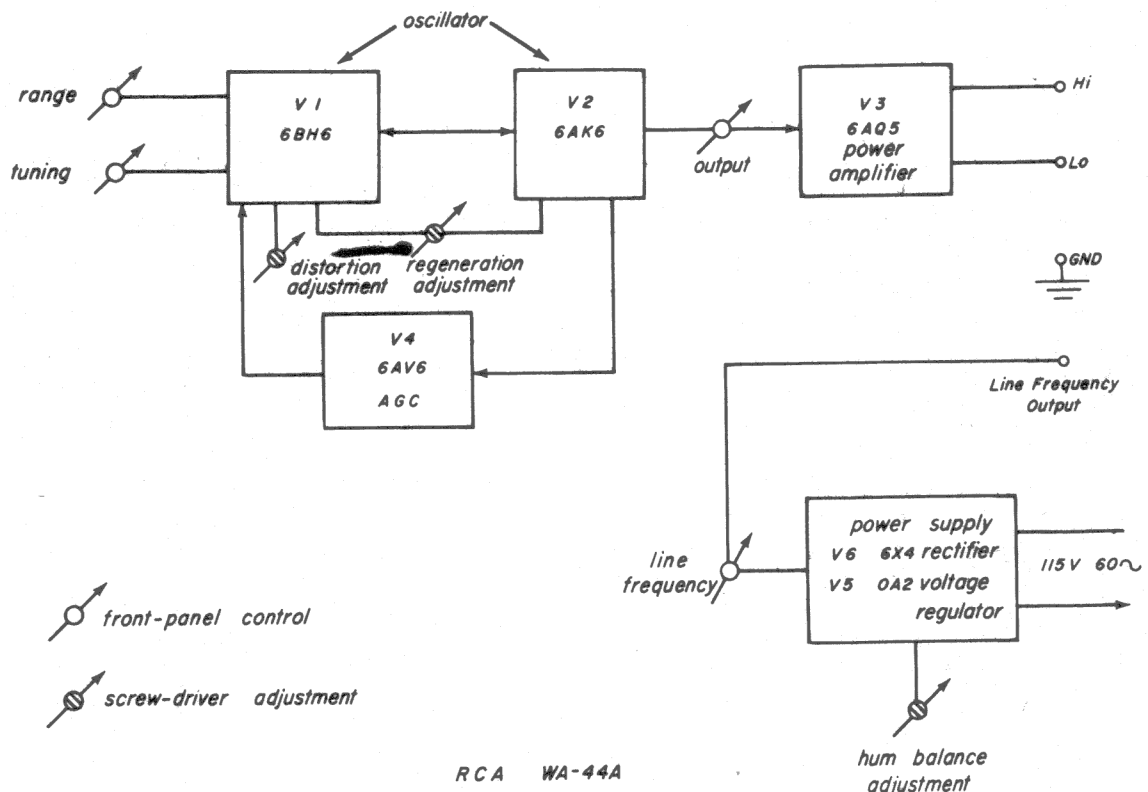
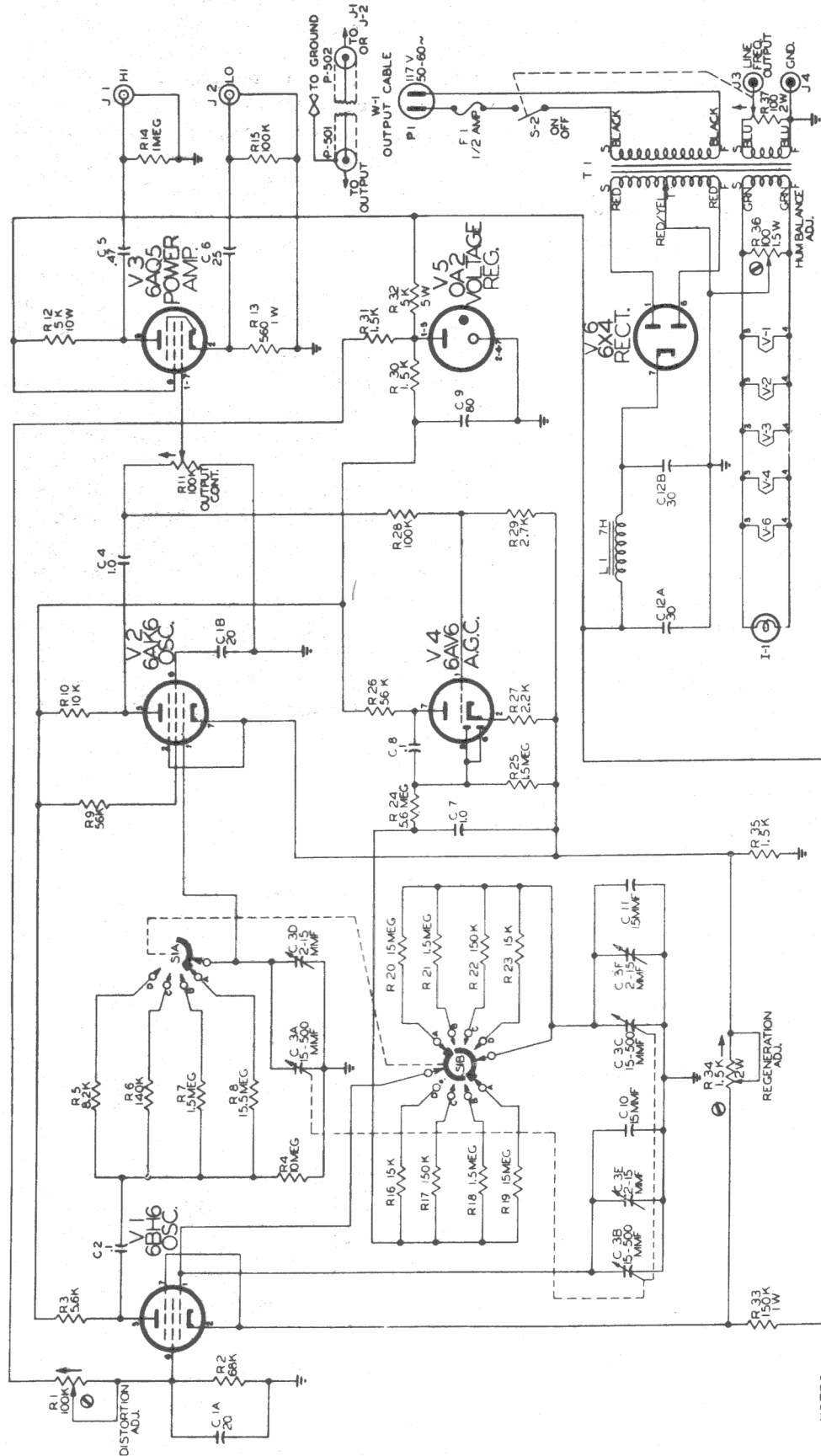


Fig. 31-24



NOTES:
 K=1000
 ALL RESISTORS IN OHMS & ARE 1/2W; ALL CAPACITORS IN MF, UNLESS OTHERWISE INDICATED.
 ALL SWITCHES SHOWN IN MAXIMUM COUNTERCLOCKWISE POSITION & VIEWED FROM FRONT.
 ⌚ SCREW DRIVER ADJUSTMENT
 DIRECTION OF ARROW INDICATES CLOCKWISE ROTATION OF CONTROL

D-266617-1A

Fig. 31-25

The O_{A2} voltage regulator tube, V_5 , provides a closely regulated B- voltage to the oscillator, output amplifier, and AGC stages and minimizes effects of line-voltage changes on the oscillator frequency and output voltage.

The advantages and unique design of the oscillator circuit and the AGC system in this generator can best be seen by reference to the block diagram and simplified oscillator circuits of Fig. 31-24 and Fig. 31-26. The two-stage oscillator section combines low-pass and high-pass RC circuits with the oscillator tubes in a selective-feedback arrangement. Proper adjustment of the feedback voltage and action of the automatic gain control tube in controlling oscillator output insure sinusoidal output over the entire frequency range.

The basic oscillator circuit shown in Fig. 31-26c, is derived from the basic arrangements shown in Fig. 31-26a and b. In the low-pass circuit, the grid circuit is made frequency selective so the output-frequency characteristics of the stage follow the curve on the right. In the simplified circuit of Fig. 31-26b, the grid is partially grounded in a frequency-selective manner so that the stage has a high-pass characteristic which follows the adjacent curve.

When the low-pass and high-pass stages are combined as shown in Fig. 31-26c, the combined response characteristics are equivalent to the combined curve XF_oY . Highest response or maximum sensitivity will occur at F_o and oscillations will occur at this frequency.

As in the case of the Wien-bridge oscillator, this circuit develops the purest sine wave when it is operated at a point near the verge of feedback necessary to sustain oscillation. Potentiometer R_1 (Fig. 31-25) adjusts the screen voltage applied to V_1 and is set at the point which provides the maximum output signal which is free of waveshape distortion and motorboating. Distortion is also avoided by limiting the feedback between V_1 and V_2 by means of potentiometer R_{34} (Fig. 31-25), and by use of the automatic gain control stage, V_4 . The switch, S_1 , changes the values of the resistors required for the four frequency

ranges. The 3-section variable capacitor, C_3 , is used to tune the oscillator to the exact frequency on any band.

The automatic-gain-control stage samples, amplifies, rectifies, and filters a portion of the output signal from the oscillator section and feeds back a negative bias voltage to the oscillator. Any increase in the signal output causes an increase in negative grid bias, reducing the amplification and causing

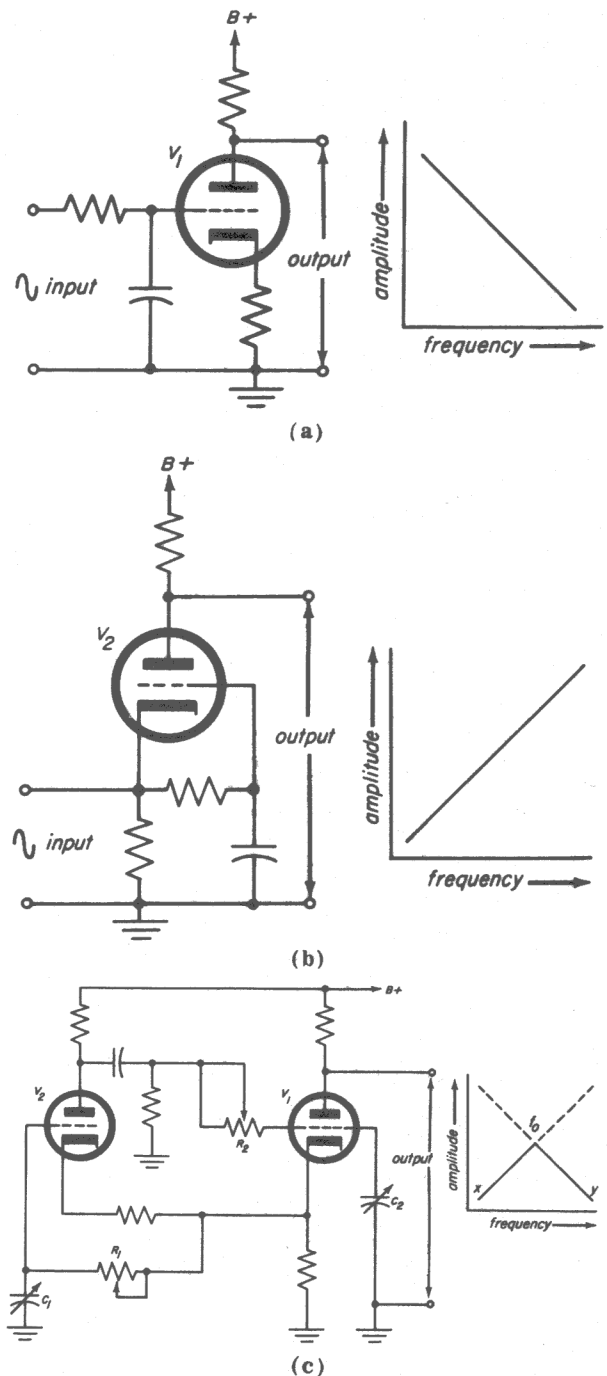


Fig. 31-26

a reduction in output signal voltage. The effects of the decrease in signal output are exactly the opposite. Output level is maintained at a constant value regardless of normal line-voltage variations and

tube drift. The WA-44A is also equipped with a voltage regulator in the power supply to minimize effects of line-voltage variations upon frequency stability and output voltage.

